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DECIDUOUS FRUIT AND TREE NUT RESEARCH

of the

United States Department of Agriculture
and Cooperating Agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
December 31, 1964

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CURRENT SERIAL RECORDS

ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology Research
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 4 - Market Quality
- 4 - Transportation and Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite
- 12 - Crops
- 12 - Entomology

Economic Research Service (ERS)

- 1, 5 - Resource Development Economics
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic and Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

Forest Service - Research (FS)

- 6 - Forest Economics and Marketing
- 6 - Forest Products and Engineering
- 6 - Forest Protection
- 6 - Timber Management
- 6 - Watershed, Recreation and Range

Other Services

- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the USDA program and progress for the following commodities and subjects:

- | | |
|--|--------------------------------------|
| 3 - Rural Dwellings | 8 - Cotton and Cottonseed |
| 6 - Forestry (Other than Forest Service) | 9 - Grain and Forage Crops |
| 7 - Beef Cattle | 10 - Citrus and Subtropical Fruit |
| 7 - Dairy | 10 - Deciduous Fruit and Tree Nut |
| 7 - Poultry | 10 - Potato |
| 7 - Sheep and Wool | 10 - Vegetable |
| 7 - Swine | 10 - Florist, Nursery and Shade Tree |
| 7 - Cross Species and Miscellaneous | 11 - Oilseeds and Peanut |
| Animal Research | 11 - Sugar |
| | 13 - Tobacco |

A copy of any of the reports may be requested from Barnard Joy, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250.

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INTRODUCTION

This report deals with research on many kinds of deciduous, small fruits, grape and edible tree nuts. It does not include extensive cross-commodity work, much of it basic in character, which contributes to the solution of problems of other agricultural commodities, as well as those of deciduous fruits and edible tree nuts. The progress on cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA AND COOPERATIVE PROGRAM, (3) PROGRAM OF STATE EXPERIMENT STATIONS, (4) PROGRESS--USDA AND COOPERATIVE PROGRAMS, (5) PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS.

Research on deciduous fruit and tree nut problems is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

Research by USDA

Farm Research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology and Agricultural Engineering Divisions of the Agricultural Research Service.

Nutrition, Consumer and Industrial Use Research. Nutrition and consumer use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service. Utilization research deals with methods of preservation of these commodities through canning, drying, freezing, or combinations of these methods and also with the origination of new forms of food products or combinations of fruits and nuts with other foods. It is also concerned with improved equipment and processes. The work is done at the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania; at the Western Utilization Research and Development Division, Albany, California; at WURDD laboratories at Pasadena, California; and at Puyallup and Prosser, Washington; and under contract with State and foreign country laboratories and in cooperation with the industry and other organizations mentioned under program for each research area.

Marketing and Economic Research. Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and Transportation and Facilities Research Divisions of the Agricultural Research Service. Economic research is concerned with market potentials for new products and uses; merchandising and promotion, economics of transportation and storage, marketing costs, margins and efficiency; market structure, practices and competition; information, outlook and rural development; supply, demand and price; situation and outlook; consumer preference; improvement of crop estimating procedures, and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service.

Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by, the State.

Privately supported research of considerable extent is done by food processors and distributors, food industry and trade associations, food container and equipment suppliers, marketing equipment and facility manufacturers, chemical and fertilizer companies, package and container manufacturers, market research institutes and corporations, nurserymen, orchardists, and grove owners. Industry's cooperation in supporting research on deciduous fruits and tree nuts in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State Stations has contributed greatly to its success.

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried tree fruits and nuts. The canning, freezing, and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at USDA laboratories, universities, and other organizations. Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry.

Marketing equipment and facility manufacturers also make sizable contributions to research on the development of equipment for handling fruits on the farm or orchard, into and out of packing houses, transportation vehicle, wholesale distribution center and in the retail establishment, as well as research on the containers in which it is moved and on the transportation vehicles from which it moves from one point in the distribution channel to another. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development, and interregional and inter-market competition.

Chemical and fertilizer companies make a significant contribution in research on the development of new materials, or combinations of materials, to produce more efficiently high quality fruits and tree nuts through better nutrition of the growing plant, control of diseases, insects, nematodes, weeds and the regulation of growth processes through use of growth regulator substances such as fruit set thinners, stop-drop chemicals, bloom retarders, etc.

There are a few private breeders of deciduous fruits and tree nuts and a number of the larger nurserymen spend considerable time and money in the search for, and testing of, new varieties in the major production areas, sometimes on their own acreage, but usually in cooperation with some grower. The contribution of growers to our overall research effort on deciduous fruit and tree nuts is substantial. Certainly, in the field of production his help is indispensable for most of the laboratory research results must finally be confirmed by orchard scale experiments. The grower cooperates with the U.S.D.A., State Experiment Stations and suppliers of many materials and equipment, usually without compensation except for the experience and knowledge gained.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Mechanization of Harvesting and Farm Handling Fruits. In cooperation with several State Experiment Stations, good progress has been made in mechanizing the harvesting and farm handling of several fruit crops, including cherries, blueberries, prunes, and dates. This is particularly true for tart cherries where labor requirements have been reduced by 75 percent and costs by 50 percent.

Significant Advance in the Potential Use of Insect Chemosterilants. Hexamethylphosphoramide (hempa) and hexamethylmelamine (hemel), dimethylamido analogs of tepa and tretamine but much lower in mammalian toxicity of formerly available materials. This discovery of less hazardous compounds may permit earlier application of sterilization control to specific insect problems.

Better Frozen Fruits and Vegetables. While conventional freezing processes usually preserve the flavor, color, and nutritive value of frozen fruits and vegetables, they often have an adverse effect on texture. In common commercial practice freezing requires from 15 minutes to many hours. The scientists found that if freezing is accomplished very rapidly--in a minute or less--such damage does not occur. Green beans frozen by intermittent immersion in liquid nitrogen, for example, have a texture essentially the same as that of fresh beans. Freezing with liquid nitrogen is probably too costly for all but high-valued products. However, other less expensive ways of achieving very rapid freezing are available and they will undoubtedly come into much wider use now that the improvement in product quality has been demonstrated. Retention of fresh-product texture in the processed product will expand the market for frozen fruits and vegetables.

Heat Treatment for Control of Decay of Fresh Fruits and Vegetables. Although heat has been used to a limited extent to control certain plant diseases for many years, the recent concern regarding chemicals in foods has stimulated research with heat as a method of decay control. Following promising results obtained by the Department with hot water treatment of peaches (published in MRR 643) one large peach grower in Georgia successfully treated his entire crop in 1964. A very large packing house in South Carolina has also installed a heat-treating tank in the packing line. There is also a successful commercial application in Florida of the hot water treatment for the control of anthracnose decay of mangos. Promising results are being obtained experimentally with hot water for control of decay of bell peppers and citrus fruits and with hot air for control of decays of strawberries, red raspberries, and blueberries.

Irradiation. Placement of a mobile gamma irradiator at the Fresno field laboratory during the past fiscal year enabled evaluation of this treatment for a wide range of horticultural crops, field crops, meats, poultry, and stored product insects under semi-commercial conditions. Postharvest decay reduction, without serious adverse effects on the quality of the commodity, was obtained with fresh strawberries, nectarines, figs, and mushrooms. Most of the other horticultural commodities treated showed adverse effects on texture, color, or flavor at irradiation dosages producing worthwhile decay reduction. With this information producers and shippers of horticultural crops can better assess the commercial possibilities of the irradiation treatment. There was a significant initial loss in sedimentation values

Development of Design for Multi-Purpose Van Container. A design for a multi-purpose van container for transporting farm and food products has been developed. When completed, the van can haul frozen and nonfrozen products as well as dry cargo. It can be moved by highway, rail, water, and possibly air. When widely adopted, and industry interest indicates it will be, the van container will bring significant reduction in the annual bill for transporting agricultural products and supplies, and at the same time furnish better protection to products which require special environment during transit.

Philadelphia Food-Distribution Center Nearing Completion. In Philadelphia, as a result of studies of the facilities used for handling food, construction is almost complete on the 388-acre food-distribution center. When completed, the development will represent an investment of over \$100 million and provide employment for about 12,000 people in handling and processing all types of food and food products and related service industries. Prior to the development of the center, the tax income from the site was \$29,000 per year and when construction is completed, will be almost \$2.0 million annually. The old market has been replaced with three apartment buildings and a number of townhouses, increasing the assessed valuation from about \$7.0 to \$27.0 million.

7. Promotional Expenditures by Producer Organizations. -- A survey of promotional expenditures of producer organizations and similar agriculturally oriented groups indicates that there are almost 1,200 of these organizations spending a total of about \$86 million annually for the promotion of agricultural products. This is an increase of nearly \$20 million over expenditures shown by these organizations in a similar survey in 1958. This increase in expenditures represents added self-help efforts by producer groups to build and strengthen markets for their products and to combat the problem of an imbalance between demand and supply. Fruit, which was the leading product promoted, and dairy, which ranked second, accounted for well over 50 percent of these expenditures. Meat and livestock products ranked third with expenditures of over \$6 million per year. Promotional expenditures for natural fibers, poultry and eggs, and field crops were comparable ranging between \$4 and \$5 million per year for each commodity class.

Voluntary producer-processor groups spent more than any of the other groups, with expenditures of nearly \$32 million per year. Cooperatives and commissions and boards operating under enabling legislation were also important, with each type of organization spending about \$25 million per year. State Departments of Agriculture and other organizations not identified spent less than the other types of organizations, with expenditures in each of these categories averaging about \$1.5 million per year.

I. FARM RESEARCH

CROP INTRODUCTION AND EVALUATION Crops Research Division, ARS

Problem. American agriculture is based on the expanding culture of crops most of which have originated outside our continental limits.

The improvement of existing crop varieties, the selection of new lines with natural resistance to insects and diseases, and the development of any number of important characteristics is dependent on a continuous flow of introduced germ plasm. Inherent in this is the preliminary evaluation and cataloging of plant introductions for traits which will be of use to plant breeders and the agronomic development of potential crops as a result of joint botanical-utilization screening research on new crops. These demands require the search for and introduction of 8 to 10 thousand plant collections and samples for analysis yearly.

USDA AND COOPERATIVE PROGRAM

The nature of this program is to conduct investigations concerned with the introduction, evaluation, and maintenance of plant germ plasm for the development of a strong yet diversified agricultural program for the United States. Research involves a continuing assessment of the world's plant resources; procurement of stocks through exploration and international exchange; the evaluation of the introductions either as breeding stocks, as potential new crops, or for land reclamation and conservation purposes, through a national cooperative research effort, and the preservation of these materials either as seed or as vegetative stocks. Leadership for this program is at Beltsville, Maryland.

Four national introduction stations are responsible for evaluation, maintenance, and/or quarantine of new introductions which require special handling: Chico, California; Miami, Florida; Savannah, Georgia; and Glenn Dale, Maryland. The responsibility for preservation of seed stocks of national interest lies with the National Seed Storage Laboratory, Fort Collins, Colorado. Cooperative new crops studies to determine significant agronomic characteristics of plants having valuable end-products are conducted cooperatively with experiment stations of Alabama, Montana, Nebraska, North Carolina, South Carolina, and Texas. Four regional and one inter-regional introduction stations deal with the evaluation of crop breeding stocks essential to programs in state experiment stations.

Ten P.L. 480 projects are currently active, all having to do with the collection and screening of native plants of potential use in the agriculture of the United States. These countries and grant amounts are as follows: Colombia (S5-CR-1) - \$113,159; India (A7-CR-52) - \$20,752; Israel (A10-CR-10) - \$115,555; Israel (A10-CR-11) - \$87,337; Korea (A13-CR-1) - \$46,692; Pakistan (A17-CR-5) - \$60,449; Spain (E25-CR-11) - \$156,583; Turkey (A22-CR-1) - \$134,444; Uruguay (S9-CR-3) - \$114,024; Yugoslavia (E30-CR-2) - \$30,000.

The Federal scientific effort devoted to research in New Crops totals 38.5 man-years. Of this number, 3.0 are devoted to international plant exchange, 3.2 to botanical investigations, 6.2 to special plant procurement and botanical activities. Research on new crop evaluation includes 8.7 man-years for horticultural research, 3.8 for agronomic studies, 6.1 devoted to evaluation of potential new crops, 4.0 to pathology, and 3.5 to maintenance of germ plasm.

PROGRAM OF STATE EXPERIMENT STATIONS

While responsibility for collecting and introducing plant material into this country rests predominantly with the Department, the State stations cooperate actively in the preservation, multiplication, and preliminary evaluation of such materials and in domestic and other explorations for the introduction of new materials. An elaborate system supported in part by the States and in part by the Department has been organized for the purpose of placing introduced materials in the hands of interested plant researchers throughout the country. This system consists of a series of 5 plant introduction stations located respectively in Geneva, New York; Experiment, Georgia; Ames, Iowa; Pullman, Washington; and Sturgeon Bay, Wisconsin. Research of the State stations is organized and coordinated through 4 regional projects and 1 inter-regional project: NE-9, Discovery and Preservation of Valuable Plant Germ Plasm; S-9, The Introduction, Multiplication, and Evaluation of New Plants for Industrial and Agricultural Use and the Preservation of Valuable Germ Plasm; NC-7, New Plants - for Industrial and Agricultural Utilization; W-6, The Introduction, Multiplication, Preservation, and Determination of the Value of New Plants for Industrial and Other Purposes; and IR-1, Introduction, Preservation, Classification, Distribution, and Preliminary Evaluation of Wild and Cultivated Species of Solanum. All 50 States and Puerto Rico cooperate in this research. Cooperation between the State stations and the Department in this program is outstanding and of great mutual benefit.

The total research effort on replacement crop introduction and evaluation at the State stations is approximately 60.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Plant Introduction

Foreign exploration. An exploration in the Soviet Union resulted in the collection of 150 fruit and ornamental breeding stocks, mostly seeds collected in the wild in Central Asia, Crimea, and Moldavia. This was the first collecting by U. S. explorers in the U.S.S.R. in 30 years.

Domestic exploration. Collecting in cooperation with the regional new crops programs resulted in the following: NE-9, 19 selections of wild highbush blueberries were added to the collection originally assembled in Maine in 1959 and a survey of low-temperature tolerant vegetable varieties used in Canada was undertaken by the Rhode Island AES; NC-7, the project

on collecting small fruits in Alaska was terminated and seed increase of Rubus collections will now be transferred to the regional plant introduction station at Ames, Iowa; S-9, 18 additional local collections of fruits were added to the Louisiana collection. The presence of virus diseases in some of the collections points up the need to index this material before any of it is released to other locations.

Maintenance of germ plasm. The primary phase of the survey of fruit and nut clones in the U. S., conducted at the request of the "New Crops" National Coordinating Committee, will be completed during calendar year 1964. Part 1, dealing with apples, and Part 2, on stone fruits, have been printed and distributed to breeders. Part 3, which includes pears, nuts, and miscellaneous fruits is in press.

B. New Crop Evaluation

Fruits and nuts. Research at Chico, California, on Actinidia chinensis, the Chinese gooseberry, has established the optimum temperatures for seed germination. Alternating the temperature, 8 hrs. at 70° F. and 16 hrs. at 50°, gave the best results. Other studies showed that the minimum threshold for the high temperature phase was between 60° and 70°. Seed held at sustained temperatures of 60° or lower failed to germinate. Research on soil fumigation treatments resulted in recommendations for production of nematode-free actinidia seedlings. Methyl bromide, 1 lb/100 sq. ft. of loose soil, can be relied upon to produce clean stock. Seedlings grown in untreated soil are usually infected with one or more nematode species.

Severe weather conditions curtailed fruiting of stone fruits at Chico, California, particularly almonds and apricots. Despite the fact that most apricots were poor, two Turkish seedlings, P.I. 248779 and P.I. 255319, set good crops, rated 4 on a yield scale of 1 to 5. Of 22 English walnut selections from the U.S.S.R., four accessions have shown extreme precociousness, producing nuts in their second and third year from seed.

Observations on orchard plantings of pistachio in California show that Verticillium wilt is a critical factor in the establishment of this new crop. If pistachio is to succeed in areas where cotton has been grown, wilt resistant rootstocks are essential. Evaluation of rootstocks for this purpose as well as for hardiness and compatibility is a major objective in the pistachio program at Chico, California.

Among the apples which came into bearing at Glenn Dale, Maryland, for the first time, 'Tohoku', P.I. 255900 (Japan) is a promising variety. It is a September bearer with attractive crimson over yellow skin, good quality flesh and flavor.

The studies at Glenn Dale on incidence of natural infection of cherry leaf spot show P.I. 186943 and P.I. 202119, seedling selections made at Glenn Dale from varieties originally from Germany, as having the highest resistance to leaf spot of all Prunus avium progenies evaluated.

Significant gains have been made in indexing Prunus introductions for viruses. Thirty-six varieties were included in the indexing program and tests were completed on 18 of these. In addition, 10 cherry varieties from material introduced in 1960 were released to breeders as virus-negative.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

- Creech, J. L., and D. H. Scott. 1964. U. S. Horticulturists Collect Plants from the USSR. Foreign Agriculture, February 3.
- Fisher, H. H. 1963. A Survey of Apple Clones in the United States. ARS 34-37-1. May.
- Fisher, H. H. 1963. A Survey of Stone Fruit Clones in the United States. ARS 34-37-2. December.

TREE FRUIT CULTURE, BREEDING AND GENETICS,
DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Deciduous tree fruit production is limited by the high cost of growing and by a lack of basic information about its culture. The fruit industry continually needs new disease-resistant scion varieties with improved horticultural tree and fruit characters and rootstock varieties that are winter-hardy, disease- and nematode-resistant, and which make young trees precocious and more fruitful. More precise information is needed about diseases and its economic control as well as about the basic physiology of fruit setting, fruit thinning, and growth. The cause and control of internal fruit disorders that originate in the orchard, such as bitter-pit and York spot, are still serious problems. The cause and control of the near-disastrous short life of peach trees in the Southeast is a particularly critical problem.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, plant physiologists, and horticulturists engaged in both basic studies and the application of known scientific principles to the solution of fruit growers' problems. Apple breeding research at Lafayette, Indiana, and at Madison, Wisconsin, and cultural and disease research at Wenatchee, Washington, is cooperative with the respective State Experiment Stations as is pear research at Hood River, Oregon, and Riverside, California. Peach breeding and varietal evaluation research at Fresno, California, is in cooperation with Fresno State College and at Prosser with the Washington Agricultural Experiment Station; disease research at Clemson is cooperative with the South Carolina Agricultural Experimental Station, and at Riverside in cooperation with the California Citrus Experiment Station. Plum breeding and evaluation research at Fresno is cooperative with Fresno State College and at Prosser with the Washington Agricultural Experiment Station. Cherry breeding and evaluation research at Prosser is cooperative with the Washington Agricultural Experiment Station; and disease research at Logan is cooperative with the Utah Agricultural Experiment Station. Apricot breeding research at Fresno is cooperative with Fresno State College.

Federal stations having deciduous fruit-tree research are Wenatchee, Washington; Fort Valley, Georgia; Mandan, North Dakota; and Beltsville, Maryland. Research at Wenatchee includes variety evaluation of pears; disease research with pear, peach, plum, and cherry; and cultural research with apple and pear. Breeding, variety evaluation, and cultural research is done with peach at Fort Valley, and with apple at Mandan. Research at Beltsville includes breeding and genetic studies of apple, pear, and peach;

diseases of apple, pear, and peach; varietal evaluation of peach; and cultural studies of apple and peach.

The Federal scientific effort devoted to research in this area totals 21.6 professional man-years. Of this number 5.1 are devoted to breeding and genetics; 10.8 to diseases; 1.1 to variety evaluation; and 4.6 to culture.

Six 5-year and one 3-year P.L. 480 contracts are currently in effect:

(1) with the Instituto Biologico, Sao Paulo, Brazil, for studies on basic research on the biochemistry of crown-gall formation (S3-CR-9), providing funds with a \$24,033 equivalent of Brazilian cruzieros, and having a projected duration from 1961 to 1966; (2) with the Israel Ministry of Agriculture for studies on the physiology of rest (dormancy) and its application to fruit growing (A10-CR-8), providing funds with an \$83,350 equivalent of Israeli pounds and having a projected duration from 1960 to 1965; (3) with the Department of Plant Pathology, University of Milan, Italy, for studies on the etiology and methods of controlling pear Moria disorder (pear decline) in Italy (E15-CR-7), providing funds with a \$61,333 equivalent in Italian lire and having a projected duration from 1962 to 1967; (4) with the Department of Fruit Breeding, Research Institute of Pomology, Skierniewice, Poland, for studies on evaluation of East-European and Asiatic fruit species and varieties recently introduced into Poland which are of value to the U. S. (E21-CR-6), providing funds with a \$24,690 equivalent in Polish zlotys and with a projected duration from 1960 to 1965; (5) with the Plant Physiology Laboratory, Research Institute of Pomology, Skierniewice, Poland, for studies on growth promoting substances and inhibitors in apple trees during different stages of its development (E21-CR-7); providing funds with a \$13,295 equivalent in Polish zlotys and with a projected duration from 1960 to 1965; (6) with the Laboratory of Plant Pathology, Institute of Pomology, Skierniewice, Poland, for studies on the epidemiology and control of apple scab (E21-CR-8), with funds providing a \$9,918 equivalent in Polish zlotys and with a projected duration from 1960 to 1965; and (7) with the Department of Biochemistry, Instituto "Jaime Ferran" de Microbiologia Madrid, Spain, for studies on the chemical and physiological changes in fungi during autolysis (E25-CR-18), with funds providing a \$24,773 equivalent in Spanish pesetas and with a projected duration from 1964 to 1967.

PROGRAM OF STATE EXPERIMENT STATIONS

Cultural research at the State Experiment Stations is concerned with problems of stock and scion relationships in tree fruits, the response of tree fruits to application of macro and minor nutrient fertilizers, the inter-relationship of nutrition with local soil types and climatic variations, the water requirements of tree fruits and the interrelationships of fertilization and irrigation, orchard and soil management studies, training and pruning of fruit trees to enhance efficiency of production and to facilitate mechanization of operations, studies on flowering and fruiting with emphasis on chemical thinning, and the effect of all such cultural studies

on the nutritive value and consumer quality of the fruit.

Through breeding and varietal investigations the State stations are endeavoring to develop disease resistant fruit of high nutritive value and consumer appeal, adapted to local conditions of growing environment, and better suited to efficient production through adaptation to mechanization. Efforts are being made to develop more effective stock plants for rootstocks.

Cultural and breeding research is supported by fundamental research in plant nutrition, in the biochemistry of the fruiting and flowering response, in anatomical investigations of the stock-scion union, and in histological, cytological, and genetic investigations of problems in breeding.

Research on disease problems in tree fruits is in progress at many of the laboratories of the State colleges and universities. Some scientists are giving special attention to the vast array of viroses of pome and stone fruit crops. Planning, coordination, and pursuit of the objectives of this research is aided by three regional research projects and one interregional research project. Identification, detection, transmission, and fundamental studies of these viruses and the diseases they incite are in progress. Through this research it has been possible in recent years to recognize that some of the most complex problems in the principal tree fruits, such as apple, peach, pear, plum, and cherry, are the result of specific virus diseases. Since many had gone unrecognized they became widely spread through plantings and in nursery stocks.

Recent discoveries in this research of pollen and nematode transmission of virus, the control of selected virus with growth regulators, and the detection of viruses in basic drawing stocks are evidence of the vigorous research in progress.

Fundamental studies on foliar diseases of tree fruits is providing new knowledge on many bacterial and fungus diseases. Some of these diseases, such as fire blight in apple and pear, bacterial spot and canker in peach, scab in apple, and leaf and blossom blight in cherry are destructive, and even limited control is costly.

Root diseases of tree fruits are being intensively studied at several locations. In some cases these are diseases that attack established plantings and kill trees. In others they make an impact on production without death of the trees, or create serious replant or establishment problems. Bacteria, fungi, nematodes, and even viruses are involved among these diseases. Replant problems in peach and apple, the winter-kill complex in peach, and nematode in peach are a few of the problems being studied. Mechanisms of pathogenesis and microbial interactions are being investigated in an effort to provide more fundamental knowledge to be used in the control of these diseases.

Fruit rots, and internal breakdowns are being investigated. The use of

sprays, dips, radiant energy, and other techniques are being tested. In addition a number of institutions maintain the necessary testing procedures required to provide the elaborate and effective spray production schedules essential to tree fruit production. The total research effort on tree fruits at the State stations is approximately 86.1 professional man-years, of which 32.2 is for culture, 17.0 for breeding and variety evaluation, and 36.9 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Apple. At Blairsville, Georgia, the breeding program to develop early maturing, high quality apple varieties for the Southeast is now in the fourth year. More than 3000 seedlings from controlled crosses are now established in the nursery or greenhouse.

2. Pear. At Beltsville, in the program to breed new high-quality fire-blight resistant varieties, 129 different forms of *Pyrus* (pear) species and sub-species have been established in a germ-plasm source orchard.

3. Peach and nectarine. At Fort Valley, Georgia, emphasis was on the development of high-quality early and late-midseason varieties having low-chilling requirements. About 60 selections were planted for test at the new Byron station nearby and future hybridized seedlings will be planted at Byron.

At Prosser, Washington, emphasis was on bud-hardy, high-quality, firm varieties adapted both to the fresh-market and to processing. Trees of 3 promising peach and 1 nectarine selections were distributed to cooperating growers for test and evaluation.

At Fresno, California, emphasis was on the development of firm yellow-fleshed, high-quality, mid-and late-season varieties. A total of 48 peach and nectarine selections are currently being tested as promising and, of these, 16 peaches and 3 nectarines have been distributed for grower-cooperator tests.

4. Plum. At Fresno, California, breeding for superior Japanese-type plums was emphasized. From seedlings fruiting in 1963, 19 were selected for further tests. Six selections were distributed for grower-cooperator trials.

5. Cherry. At Prosser, Washington, hardier, rain-cracking resistant sweet cherry varieties of comparable size and quality to the Bing variety are sought. An early Napoleon-type selection continues to show commercial promise as an early companion variety to Rainier. Two particular promising selections were propagated for distribution and grower tests. Commercial quantities of fruit from the Chinook and Rainier varieties, introduced by the Department in 1960, are now available from Pacific Northwest shippers

and processors.

6. Apricot. At Fresno, California, large high-quality varieties resistant to pit-burning are needed. The variety Castleton, which ripens with Newcastle but is superior in size to that variety, was named and introduced. Two additional selections are being evaluated as outstanding potential varieties.

At Fort Valley, Georgia, a program was initiated to develop high-quality, low-chilling requiring apricot varieties for the Southeast. Earliest seedling progeny from this program was started in the greenhouse at Fort Valley but will be field-planted at Byron, Georgia.

B. Diseases

1. Apple. Apple scab. Research to study apple scab is sponsored by the United States, in Poland, under provisions of P.L. 480 Project E21-CR-8 entitled epiphytology of apple scab. The most recent research from this project, started in 1960, indicates that extreme low temperatures interfere with ascospore development of the scab fungus and delayed spore formation resulted in spore-discharge over a longer than normal period. Infecting-spore discharge is more accurately forecast under conditions of low, rather than high, barometric pressure. The critical period for fungicide coverage was during period of rapid leaf growth. Fungicides should be applied within 12 days of infection. Captan and DNRB were the most, and lime-sulfur and the carbamates the least, durable under conditions of high rainfall.

Viruses. At Wenatchee, Washington, five mechanically transmissible viruses from apple sources have been identified: apple latent virus 1, apple latent virus 2, tobacco mosaic virus, an unknown virus similar to stone fruit ringspot, and a virus of Red Delicious which causes flat apples and foliar symptoms similar to prune crinkle.

A virus complex of sour cherry yellows and necrotic ringspot has been transmitted from Montmorency sour cherry to a Russian apple clone and back to healthy Montmorency without changing the characteristic symptoms on sour cherry.

At Riverside, California, 8 commercial apple varieties were demonstrated to be symptomless carriers of the Prunus ringspot virus.

2. Pear. Fire blight. At Beltsville, Maryland, initial studies of the nature of fire blight resistance indicated that resistance was associated with the presence of the glucoside arbutin and the subsequent accumulation of other naturally occurring substances. Greenhouse experiments indicated that the fire blight bacteria remain viable on pear foliage for longer periods than previously suspected without causing visible symptoms of infection.

Pear decline. In California pear decline is still considered the most serious disease of pome fruits. Work done at Riverside has demonstrated that the "brown-line" disorder at the graft union is not a reliable diagnostic symptom of pear decline. Growth and fruiting of Bartlett continues to be better on domestic, rather than on oriental, pear rootstocks.

Research to study pear decline in Italy is sponsored by the United States under provisions of P.L. 480 Project E15-CR-7 entitled the etiology and methods of controlling pear Moria (decline). Moria of southern Europe and Italy and pear decline of the United States are probably identical. Initial tests with insect psyllids, while they show feeding injury, have failed to cause pear decline. Considerable evidence has developed in the United States to indicate that pear decline is a virus disease.

Antimicrobial plant extracts. Twenty-one extracts have been found, from among 125 plant species, to have antibacterial and antifungal properties.

3. Peach. Bacterial canker. This disease can be spread by contaminated pruning shears, and pruning during midwinter is less infective than during fall or early spring.

Peach mosaic virus. The 1963 Federal-State-County cooperative inspection of southern California orchards for peach mosaic revealed 200 infected trees (0.24 percent), about one-half the number of infected trees found during the previous year. The varieties Blazing Gold, Dixigem, Keystone, and July Elberta tend to recover readily from the shock-stage of infection whereas Babcock and Halehaven recover slowly.

4. Sweet cherry. X-disease virus. In Utah, the natural spread of X-disease continued unabated despite the removal of diseased trees. The disease is no longer of economic importance in the principal Washington peach and cherry areas where the usual spray programs effectively suppress the insect vectors of the virus. The variety Dicke Braune Blakenburger is resistant to the virus and, although the variety's fruit size and quality are inferior, it is valuable as a source of resistance for varieties in areas where vector control is impractical.

Little cherry virus. Little cherry is one of the most serious virus diseases of sweet cherries and particularly affects late dark-fruited varieties. During 1963, in Utah, the first evidence of natural spread of this disease was noted.

Twisted leaf virus. Index studies of this virus at Wenatchee, Washington, showed it to be caused by a single virus and not by a virus-complex as previously reputed. Varietal tolerance studies have shown some sweet cherry varieties to be symptomless carriers of the disease.

Rough fruit virus. In Utah a new disease called rough fruit virus was discovered and described. The disease appears to have been introduced on

some Iranian sweet cherry varieties imported for testing.

Mottle leaf virus. In the canyon and foothill sweet cherry districts of Washington, mottle leaf virus continues to spread from the native Prunus emarginata. Varietal tolerance studies have shown the following ones to be symptomless carriers of the virus: MarMac, Bigarreau, Cardofer Fruhe, Fruhe Werdershe, Chinook, and Rainer; Prunus serotina is immune.

Rusty mottle virus complex. Cross protection studies showed mild rusty mottle virus delayed symptom expression of severe rusty mottle virus.

Miscellaneous. A sweet cherry seedling from the breeding program at Prosser, Washington, was an excellent indicator plant for a variety of virus diseases and could replace the two standard indexing varieties, Bing and Lambert, now used.

A new virus disease which severely stunts infected trees was found near Wenatchee, Washington, and is called Vein mottle. Varietal tolerance studies showed Lambert and Bing to be severely affected; Van, Windsor, Rainier, Napoleon, and Schmidt to be moderately affected; and Chinook to be mildly affected.

5. Sour cherry. Sour cherry yellows, necrotic ringspot, prune dwarf complex. Studies in Wisconsin indicate that the virus causing prune dwarf in Italian Prune and yellows in sour cherry are closely related and possibly identical. The ringspot virus appears to be a common contaminant. Evaluation of sour cherry introductions in Wisconsin indicate 19 that are virus free, winter hardy, and show horticultural promise.

6. Apricot. Ring pox virus. In Washington two forms of ring pox disease, regular and pit, have been differentiated on indicator plants. In California, however, pit pox has been described as a varietal manifestation of the ring pox virus. Peach mosaic was demonstrated to reduce the growth and yield of apricot trees. When mosaic and ring pox viruses occur simultaneously in apricot, the leaf symptoms of mosaic and the fruit symptoms of ring pox are both intensified.

7. Crown gall of stone fruits. Basic research on the biochemistry of crown gall formation is sponsored by the United States, in Brazil, under provisions of P.L. 480 Project S3-CR-9. Indoleacetic acid (auxin) was found in both healthy and diseased rosaceous plant tissues but there was more of the auxin in the healthy than in the gall tissue.

C. Varietal Evaluation

1. Apple. At Wenatchee, Washington, based on the development of scald and watercore in storage, the spur-type mutants of Red Delicious were found to be later maturing than the conventional strains. The spur types were also found to be generally poorer in quality.

2. Peach. At Fresno, California, newer peach varieties from state experiment stations and proprietary sources such as Earli Glo, Collins, Sunhaven, Richhaven, Redwin, Garnet, Marcus, Redgold, Lategold, Goldenred, and Goldgem all developed soft tips and sutures. None appeared well adapted to the San Joaquin Valley. Of the varieties ripening during the 2-month period between the early Springtime variety and Elberta, 90 percent of the peach trees sold by California nurseries were of varieties originated by the Department.

At Beltsville, Maryland, the proprietary varieties Suncrest, Redtop, and Goldenred were promising whereas the variety Marcus was very susceptible to split pits.

3. Cherry. At Prosser, Washington, in a variety test of almost 200 sweet cherries of foreign origin, 13 have shown exceptional cold hardiness in laboratory tests. Chinook in laboratory tests had more wood cold hardiness than Bing but less than Rainier and Van and indicated that Chinook is probably more hardy than previously claimed.

4. Apricot. At Fresno, California, the Castleton variety introduced by the Department in 1963 for its superior size and firmness and resistance to pit burning, appeared better adapted to the San Joaquin Valley conditions than the currently standard Newcastle variety.

5. Public Law 480 Research. Under United States sponsorship in project E21-CR-6, phenological and pomological information has been collected for several years on a variety of deciduous fruits introduced into Poland from China and the Soviet Union.

D. Culture

1. Apple. Nutrition. At Wenatchee, Washington, sulfur was found to be deficient in orchards irrigated with water containing little or no sulfur. The sulfur deficiency was readily corrected by sulfur-carrying fertilizers or sprays. The mineral nutrition survey by foliar analysis of 150 Washington apple orchards has shown that the number of growers applying luxury amounts of nitrogen to their orchards has decreased from 40 to 15 percent during the last 5 years.

Temperature. Cool night temperatures for 3 weeks following full bloom reduced final fruit size but not fruit shape, whereas high temperatures during the same period altered fruit shape but not size. Parathion sprays cause more fruit russeting during low, rather than during high, night temperatures.

Fruit Thinning. Continued success with Sevin (Carbaryl) as a fruit thinning agent was obtained at Wenatchee, Washington. Sevin or its metabolites interfere with the nutrient transport system of the developing fruit. The consistent results with Sevin was found to be associated with the site of

chemical absorption. Other chemical thinners are absorbed by the leaves and translocated to the fruit, and the rate of this foliar absorption and translocation, and subsequently the fruit thinning action, is dependent upon temperature and humidity. Sevin is absorbed directly by the young fruit and the mechanism of absorption and translocation is much less dependent upon environmental conditions.

Growth Retardants. B-nine, N-dimethyl amino succinamic acid, continues to look promising as a growth retardant for reduced size control of fruit trees. The number of nodes is unaffected but the length of the internode is shorter, individual leaves are larger, but the size of the fruit was reduced by 10 percent.

Experiments with labelled B-nine indicate that B-nine is rapidly translocated in apple trees and tends to remain unchanged in the plant.

2. Peach. Rootstocks. Tests in the Fort Valley, Georgia, area indicate Nemaguard is the best nematode-resistant rootstock available. However, these tests also indicate trees on Nemaguard rootstocks are shorter-lived than those on seedlings of Lovell or Elberta.

Peach Replanting. At Fort Valley, Georgia, in a cooperative experiment with the Georgia Agricultural Experiment Station, size of trees planted in soils treated with 3 soil fumigants continued to be significantly larger than those on untreated soils.

Public Law 480 Research. The physiology of rest (dormancy) and its application to fruit growing was studied in Israel under United States sponsorship in P.L. 480 project A10-CR-8. Recent research showed that cyclic high and low temperatures were more effective than uniform temperatures to influence naringenin content of peach buds. Naringenin is one of a family of naturally occurring yellow pigments in plants, low levels of which are associated with bud break of peach leaf and flower buds. Most recent studies showed that peach flower buds open in darkness but that leaf buds require light to open. The effect of light on naringenin content per se must yet be determined.

3. Cherry. Rootstocks. At Prosser, Washington, Van sweet cherry continued to out-produce Bing and Lambert on all rootstocks. Cion-variety fruiting was more precocious on mahaleb than on mazzard understocks.

Chemical Growth Retardants. At Wenatchee, Washington, B-nine showed promise to control cherry tree size. Sprayed trees had one-half the growth, and fruit ripened earlier than that of unsprayed trees.

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SMALL FRUIT CULTURE, BREEDING AND GENETICS,
DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. New improved varieties of small fruits and grapes are needed that have broad regional adaptation suitable for modern commercial use. Needs include large (for ease of picking), firm-fruited (for best handling), disease-resistant varieties for freezing and for long distance or local marketing, with a sequence of ripening throughout the season. Determination of causal agents of new diseases is needed, and methods should be developed for effective and economical control of important fungus, nematode, and virus diseases of berries and grapes, with emphasis on identification and control of viruses in strawberries, raspberries, and grapes. The testing and critical evaluation of varieties for yield and important horticultural characters, such as fruit size, firmness, color, and quality are needed in relation to regional adaptation. Also needed are improved cultural practices in propagation and plantation management that will result in high production of good quality fruit and reduced production costs. This entails new information on environmental factors limiting production and on inter-relationships of temperatures, soil moisture, diseases, and nutrition on plant growth, hardiness, and productivity.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, and horticulturists engaged in both basic studies and the application of known scientific principles to the solution of growers problems. European bunch-grape breeding, disease, varietal evaluation, and cultural research at Fresno, California, is cooperative with the Fresno State College. Strawberry breeding research at Salisbury, Maryland; Willard, North Carolina; and Corvallis, Oregon, is cooperative with the respective State Experiment Stations; and in addition, strawberry breeding and cultural work at Carbondale, Illinois, is cooperative with Southern Illinois University. Raspberry and blackberry breeding research at Corvallis, Oregon, and Carbondale, Illinois, is cooperative with the Oregon Agricultural Experiment Station and Southern Illinois University, respectively. Blackberry cultural research at Corvallis, Oregon, is cooperative with the Oregon State Agricultural Experiment Station. Blueberry breeding research at Gainesville, Florida; Tifton, Georgia; Jonesboro, Maine; and Ivanhoe, North Carolina; and breeding and disease research at Hammonton, New Jersey, is cooperative with the respective State Experiment Stations. Cranberry breeding research at East Wareham, Massachusetts; and disease research at New Brunswick, New Jersey, is cooperative with the respective State Experiment Stations. Breeding research (strawberries and raspberries) is done at the USDA Horticultural Field Station, Cheyenne, Wyoming. Breeding, disease, varietal evaluation, and cultural research with Eastern bunch grape, and breeding research with muscadine grape, is carried on at the USDA Horticultural Field Station, Meridian, Mississippi. At Beltsville, Maryland, breeding, variety

evaluation, and disease research is done with Eastern bunch grape, strawberry, blackberry, blueberry; and cultural studies are done with the Eastern bunch grape, blueberry, blackberry, and strawberry.

The Federal scientific effort devoted to research in this area totals 12.5 professional man-years. Of this number 5.9 is devoted to breeding; 4.5 to diseases; 1.1 to variety evaluation; and 1.0 to culture.

PROGRAM OF STATE EXPERIMENT STATIONS

Cultural research on small fruit at the State stations is concentrated on strawberries, blueberries, grapes, and cranberries; with only limited research on raspberries, blackberries, other brambles, and elderberries. Research is underway to study fertility levels, fertilizer placement, nutrient sources, and mulches in relation to strawberry production. Research with blueberries includes investigation of the effect of pH on plant growth, mineral nutrition, methods of propagation, and pruning. Grape investigations include mineral nutrition, spacing, effect of plant regulating chemicals on growth and fruiting, rootstocks, and efforts to mechanize pruning and harvesting. Soil and nutrient requirements of cranberries are being investigated.

Breeding and varietal research is underway with strawberries, blueberries, grapes, cranberries, blackberries, raspberries, dewberries, and elderberries. Such research is designed to increase efficiency of production through better locally adapted varieties combining disease resistance with good horticultural type, high nutritive quality, and consumer appeal. Consumer acceptance is evaluated through chemical evaluations of nutritive quality and taste panel reaction. The fruit is processed and consumer acceptance of the processed product is evaluated. The breeding and varietal studies are supported by fundamental investigations of genetics and cytogenetics.

Scientists at the State stations are providing effective research programs on diseases of small fruits in all of the principal producing areas. The wide range of climatic and soil conditions under which these crops are grown, in addition to the rapid changes in variety and in harvesting requirements, complicates the development of effective disease control. Station scientists are conducting research on the destructive viruses of strawberry which is leading to the development of more effective systems for the elimination of these diseases. Leadership in research on the nematode transmission of virus diseases of small fruits continues at several stations. Research on fruit rots in grapes and new knowledge on enzymatic relationships in these diseases is providing substantial contributions. A number of diseases of strawberry, bramble, and grape require specialized chemical controls, which are being made more effective and less costly through research. Effective treatments for the control of berry rots at harvest and transit are also being developed through research at the State stations.

The total research effort on small fruits at the State stations is approximately 44.0 professional man-years, of which 18.5 is for culture, 22.0 for breeding and variety evaluation, and 3.5 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Grape

a. American bunch grape. In breeding work at Meridian, Mississippi, and Beltsville, Maryland, 53 new selections were made of which 3 appear especially promising because of large, high quality fruit. At Meridian, 8 vigorous and productive selections tolerant to Pierce's disease are being tested as potential varieties.

b. Muscadine grape. State Experiment Stations and growers in the Southeast are testing 6 of the Department's perfect-flowered muscadine selections originated at Meridian.

At Meridian, 5 tetraploid muscadine varieties are being used as parents for their vigor and hardiness. Berries of tetraploid Dulcet, Higgins, and Hunt are one-third to one-half larger than from diploid plants of the same varieties.

c. European bunch grape (Vinifera). At Fresno, California, the most promising selections are: F 35-33, an early white seedless grape; F 26-55, a mid-season red grape; and F 27-31, a mid-season seeded black grape. Two newer selections, the F 58-93, a mid-season white seedless grape, and F 15-122, a late black seeded grape, appear promising.

A genetic study of the inheritance of the seedless character indicated that seedlessness is a recessive character governed by more than one gene and that seedless varieties vary in the number of genes they possess.

When Thompson Seedless was grafted on grape seedlings that had failed to fruit in 5 years, normal growth and fruiting occurred with Thompson which indicated that the nonfruitfulness in the seedlings is genetic rather than a disease condition.

2. Strawberry. At Willard, North Carolina, 2 advanced selections were distributed for further tests and propagation as potential varieties. These selections are NC US 2486, a hybrid of Albritton x Md-US 2101, and NC US 2655, a hybrid of Albritton x Midland.

In Maryland, selection Md-US 2601 is a potential new variety. At Corvallis, Oregon, 1 Oregon-US selection, and at Carbondale, Illinois, 8 Southern Illinois-US selections were propagated for extensive advanced testing.

Three selections, Md-US 2593, 2601, and 2700 were still promising for south-central United States; and another one, Md-US 3365, was particularly resistant to red stele Race A-5 in screening tests. Several Fragaria chiloensis selections from Oregon and California were highly resistant or immune to red stele in greenhouse bench tests. Some of these gave a high proportion of resistant seedlings when hybridized with cultivated varieties.

At Beltsville, a germination test revealed that strawberry seeds 17 years old and stored in a refrigerator at 35-40°F. were still highly viable.

3. Raspberry. At Carbondale, Illinois, every red raspberry clone derived exclusively from Rubus idaeus x strigosus parentage had some winter injury in 1962-63. Most clones derived in part from one or more Asiatic species were resistant to winter injury and all of them had marked resistance to leaf spot. The NC US 223 selection appears particularly promising for upper and middle-southern United States and is being propagated for commercial trial. Several selections of colchicine-induced tetraploid R. parvifolius x cultivated varieties were large-fruited and productive and tended to be resistant to Septoria leaf spot.

At Cheyenne, Wyoming, seed collected in the wild from the Big Horn Mountains of central Wyoming have produced seedlings that produce ripe fruit in July on current season's canes. Such a feature is particularly desirable in that area where biennial fruit canes are winter killed.

4. Blackberry. At Beltsville, Maryland, 2 thornless blackberry selections, US 1493 and US 1503, were promising and will be named and introduced as soon as sufficient stock plants are propagated. At Corvallis, Oregon, 2 thornless blackberry selections, US 1278 and US 1282, were outstanding in frozen pack and canning tests and are being propagated for extensive advanced evaluation. The Department's selection US 1063 continues to be hardy and otherwise promising for northern Washington.

5. Blueberry. In New Jersey, 3 high quality selections have consistently borne full crops in seasons when other varieties have had light crops. The three selections are being propagated as rapidly as possible; two of them, G-107 and G-111, for further extensive testing and one, G-71, for naming and introduction.

In Michigan, the Department's Bluecrop variety had a good crop during a severe drought which generally reduced crop and berry size.

In North Carolina, selection NC 678 is tentatively scheduled for naming and introduction as an early, large, canker-tolerant highbush variety for the South.

B. Diseases

1. Grape. Virus diseases. In California, studies of leaf roll virus were the most important of the 8 known grape viruses in that state. The presence of a mild strain of leaf roll in the plant does not protect a susceptible variety from infection by a more severe strain. Leaf roll virus appears to be uniformly distributed in the canes of infected plants.

In indicator tests, corky bark virus symptoms were made manifest in one season, instead of the usual 2 to 3 years, by using sensitive index varieties such as Mission, Baco 22-A, LN-33, Bokay, and Gasconade. Natural spread of corky bark virus has not been observed.

Astroid mosaic was detectable within 2 months by inoculating to St. George indicator vines in the greenhouse in spring.

Fan leaf virus, as well as Xiphinema index nematode, persisted for at least 4 years in detached but living root fragments of infected vines in soil.

Heat treatment methods to free plants of virus have yielded virus-free clones of Calmeria, Cardinal, Ribier, and Emperor. Heat-treated virus-free Cardinal vines fruited for the first time at Davis, California, and fruits matured about 3 weeks earlier on virus-free than on infected vines.

Index studies showed that early California vineyards in which vines were on their own roots were probably virus free. A survey of Arizona vineyards revealed that most plantings of the major table grape varieties, except Thompson Seedless, were extensively virus infected.

2. Strawberry. Virus diseases. At Corvallis, Oregon, screening tests for tolerance to strawberry yellows virus complex demonstrated selections having a high degree of tolerance although none were immune to the virus.

At Beltsville, Maryland, plants of 7 varieties freed of Latent-A virus, had runner plant increases up to 225 percent more than infected plants. Certain strawberry varieties have been freed of heat-stabile viruses by the aseptic propagation of very small excised runner tips. A virus-free clone of Northwest and one of Rockhill obtained by propagating excised runner tips are available to strawberry plant nurserymen.

Fungus diseases. Red stele. Greenhouse tests at Beltsville, showed several Potentilla species to be susceptible to the red stele fungus. Potentilla glandulosa, a common pasture weed of the Pacific Coast, is potentially a wild host of the red stele fungus in the West.

Fruit rots. In laboratory tests at Beltsville, the varieties Siletz, Stele-master, and Md-US 2289 were very susceptible, whereas NC 2411, NC 2355, and Redgauntlet were relatively resistant, to grey mold fruit rot.

3. Raspberry. Virus diseases. The leading eastern red raspberry variety, Latham, is universally infected with one or more of the raspberry mosaic viruses. The need for screenhouse protected foundation stock was demonstrated as essential for the extensive commercial propagation of substantially virus-free plants. Stocks of Latham freed from the mosaic viruses are now available to commercial growers.

4. Blueberry. Virus diseases. The debilitating red ringspot and necrotic ringspot viruses were found to be of widespread occurrence in blueberry plants in New Jersey. The vector of these viruses is not yet known.

Fungus diseases. In New Jersey, fungicide trials to determine the best chemicals and application timing to obtain maximum control of blueberry fruit anthracnose showed the need for use of the regularly recommended standard fungicides during the season from mid-bloom through harvest.

C. Variety evaluation

1. Grape.

Grape rootstocks. In California, experimental tests of the rootstock selection 16-154 over a wide variety of conditions demonstrated its superiority in practically every way to the commonly used 16-13 rootstock. A 14-year rootstock trial at Meridian, Mississippi, was terminated. Delaware grafted to Vermorel, riperia x rupestris 161-49, and Dog Ridge had heavy yields with moderate vine growth. Delaware grafted on Cynthiana, Barnes, and Leverkusen grew poorly or did not survive.

D. Culture and Physiology

1. Grape. In California a new and highly successful method was developed for use to propagate vinifera varieties on compatible rootstocks. The graft union is callused before field planting and then the scion is covered with wax and the rootstock planted with the graft union above the soil to prevent scion rooting in the vineyard.

At Beltsville, Maryland, a 2-year study of the methyl anthranilate content of grapes showed 15 of 25 varieties to be without the naturally occurring chemical which gives certain varieties a distinctive aromatic character. Loretto and US-909-5 had high amounts, and Concord and Niagara had intermediate amounts of the aromatic ester.

2. Strawberry. Field studies at Beltsville indicated that gibberellic acid sprays applied to Albritton plants 2 months before bloom hastened fruit ripening by 10 days. Runner production was increased nearly 50% on Gem and Earlidawn when plants set in the field in April were sprayed with gibberellic acid in May or June.

At Carbondale, Illinois, a test with three varieties showed that there was no significant advantage of post-harvest mowing to the following year's yields. Another test showed that plot size of variety trials could be reduced by one-half without sacrificing accuracy of the test.

3. Blueberry. Blueberry propagation studies with hardwood cuttings, at Beltsville, indicated that open sky propagation gave better rooting and larger plants than cuttings in 50 percent shade. Media tests indicated that a 1-1 mixture of sand-peat was the most satisfactory and that incorporation of sawdust into the mixture was harmful. Cuttings that were stored beginning in late November and taken at monthly intervals to April 1, all rooted equally well. Optimum cutting length was in the range of 3 to 7 inches. Cuttings taken from the basal and intermediate portions of the shoots rooted better than terminal cuttings. Bluecrop rooted poorest of the major varieties.

The growth regulating chemical B-Nine (dimethyl amino succinamic acid) tended to promote fruit bud formation in seedling blueberry plants.

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TREE NUT CULTURE, BREEDING AND GENETICS,
DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Tree nut production in the United States is much below the national consumption and needs to be materially increased. Production is limited by the need for better varieties that are more productive, disease resistant, of better quality, and less subject to spring frosts. More information is needed on nutritional requirements and the factors that induce biennial bearing. Diseases are often limiting factors and may even cause complete crop failure. Almonds are particularly subject to late frosts; later blooming varieties are feasible. Nut trees are known to have higher potassium requirements than the trees can absorb in heavy crop years. Methods of inducing increased absorption are needed. Tree nut crops have relatively low per acre production. New information is needed on tree spacing, dwarfing, rootstocks, and chemical fruit setters as well as more productive varieties to increase production per acre.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving breeders, plant pathologists, soil scientists, and horticulturists engaged in both basic studies and the application of known principles to the solution of growers' problems. Almond breeding research at Fresno, California, is cooperative with the California Experiment Station. Filbert breeding and cultural research at Corvallis, Oregon, is cooperative with the Oregon Experiment Station. Pecan breeding, variety evaluation, disease control and cultural studies at Meridian are cooperative with the Mississippi Experiment Station. Disease control and orchard management at Albany, Georgia; disease control, orchard management and nutrition at Shreveport, Louisiana; variety evaluation, orchard management and breeding at Brownwood are at Federally operated stations. Research on walnut diseases and culture at Corvallis, Oregon, is cooperative with the Oregon Experiment Station. Breeding research and variety evaluation (chestnuts, filberts and hicans) is carried on at Beltsville, Maryland.

The Federal scientific effort devoted to research in this area totals 11.5 professional man-years. Of this number 2.0 is devoted to breeding; 2.0 to diseases; 1.5 to variety evaluation; and 6.0 to culture.

PROGRAM OF STATE EXPERIMENT STATIONS

Several States are interested in the problem of alternate bearing in the pecan and have research projects dealing with factors affecting fruit bud initiation, fruit set, and fruit development. Soil moisture relationships and nutritional requirements of the pecan are under investigations. The

cultural problems of the walnut, almond, and filbert are also being studied.

There is little breeding work on nuts at the State stations, although a number of stations are testing varieties for local adaptation. New Mexico has an active breeding project on pecans in which it is endeavoring to produce new varieties adapted to the southern part of that State. New York is breeding filberts for adaptation under its conditions, and the California station is breeding almonds. Hawaii has an interesting project on variety selection and testing of the Macadamia nut.

Research in the State stations on disease problems in tree nut culture includes a number of distinctly different crops, grown under widely different environmental conditions, and subject to an extensive array of diseases. Current work on walnuts involves the use of preplant and post plant treatments for nema control. Both walnut and almond have through this research found to be hosts for the virus vector Xiphinema americanum. Another destructive nematode, the ring nematode C. xenoplax has been found to attack walnut. Important new research on verticillium disease of pistachio nut, which threatens this new industry, offers much promise. Almond, which has a natural ability to recover from Verticillium wilt, is also being investigated for answers to these perplexing diseases. New research on the aerial application of fungicides and the use of dormant eradicants for more efficient control of scab in pecans is providing much new and useful knowledge. Basic studies on selected pathogens are contributing fundamental knowledge of value in many areas of scientific investigation.

The total research effort on tree nuts at the State stations is approximately 3.8 professional man-years, of which 2.0 is for culture, 1.8 for breeding and variety evaluation, and -- for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Almond. The breeding program at Fresno, California, was accelerated by the use of nursery soil fumigation which improved seedling growth and reduced by one to three years the length of time required to bring seedling progeny to flower and fruiting.
2. Filbert. At Corvallis, Oregon, ten selections and varieties were found to have better filled nuts than Barcelona, the standard variety in that area.

At Beltsville, Maryland, blank nut production continued to be a puzzle and about one-fifth of the 1963 crop was without kernels. Cytological research indicated that chromosomal irregularities during early stages of pollination and fruit set were related to the problem.

3. Chinese Chestnut. At Beltsville, Maryland, three late bud breaking, late blossoming, reliably productive seedlings were selected for further test. These seedlings have promise for nut production in the more northern areas.

4. Walnut. At Corvallis, Oregon, 30 selections had nuts with more kernel than the standard Franquette variety the nuts of which average 42 percent kernel. One selection had almost 60 percent, and 14 others had more than 50 percent kernel. Most of the selections with the well-filled nuts were Manregian seedlings.

B. Diseases

1. Walnut. Walnut blight (Bacteriosis). At Corvallis, Oregon, air-blast sprays of tribasic copper sulfate (4 lbs./100 gals. water) and Bordeaux mixture effectively controlled bacteriosis in the field.

For the fifth consecutive year, in Oregon, the Howe variety is appreciably more resistant to bacteriosis than the more popular Franquette. In a variety collection never sprayed for walnut blight, the relative natural occurrence of blight on 5-year-old trees ranged from 3 to 100 percent incidence as follows: Franquette (3%), Broadview, Adams, Carpathian 3, Hartley, Spurgeon, Parrott, Garmor, Moyer, Schaeffer, US 4946 (60%), UC 5248, Jensen, Carpathian 1, and Nuggett (100%).

2. Pecan. Pecan scab. In tests at Fort Valley, Georgia, foliage scab failed to develop because of dry weather early during growth. However, some scab developed on the nuts in June but this was effectively controlled with one application of dodine applied by hydraulic sprayer. At Albany, Georgia, the fungicide cupric omadine was promising to control scab on the Schley variety. At Meridian, Mississippi, dodine at the rate of 1 lb./30 gals. water and mist-sprayed was the most effective fungicide to control scab on Schley.

Powdery mildew. In Georgia, good control of powdery mildew on Pabst variety resulted from 3 applications of karathane plus dodine. At Meridian, Mississippi, the multiple carbamate 'Polyram' (4 lbs./30 gals. water) mist-sprayed was the most effective of the fungicides tested to control powdery mildew on Schley.

Crown gall. Terramycin antibiotic continued to effectively control crown gall on pecan trees.

C. Variety Evaluation

1. Walnut. In Oregon, open-pollinated seedlings of the Manregian variety continue to be notable in commercial orchards because of their characteristic well filled nuts combined with other favorable horticultural characters.

Seedlings of Manregian and Carpathian varieties, from seed of four selected sources, continue to be in demand as rootstocks.

2. Pecan. At Meridian, Mississippi, the filling of pecan nuts was generally poorer than normal for most varieties because of a heavy crop but the nuts of Desirable, Elliot, and Philema were well-filled despite the heavy production. Peruque tends to be unsuited to culture at Meridian but it was noted to be well adapted and productive on native rootstocks in Western Kentucky.

D. Culture and physiology

1. Filbert. Chemical growth regulators. Two growth-regulating chemicals show promise to increase yields of filberts; 2,4,5,TP and B-Nine (dimethyl amino succinamic acid) increased the yield by almost one-third in initial tests at Beltsville, Maryland.

The B-Nine chemical spray dwarfed rapidly growing filbert sucker shoots and promoted the formation of staminate catkins.

Pruning tests. The 5-year test of rejuvenation pruning of crowded filbert orchards, in Oregon, was terminated. Pruning was beneficial to improve yields. Heavy pruning of every 5th row each year was no better to increase yields than pruning all trees lightly each year. However, the systematic heavy pruning was the more efficient method and is recommended and particularly since it tends to overcome the alternate bearing habit of the Barcelona variety.

Training. At Corvallis, Oregon, 4-year-old trees spaced 15' x 15' and trained to a single trunk were easier to harvest and had yields that were double those of bush-type trees.

Storm-damage recovery. The typhoon that struck the Pacific Northwest in October, 1962, uprooted an estimated 35 percent of Oregon's mature filbert trees. The Department's recommendation to growers to reset uprooted trees and prune them somewhat heavily has saved 90 percent of the dislocated trees to the distinct economic advantage of the growers.

Mineral nutrition. In Oregon, nitrogen was the most, and potassium the next most, important element affecting the yield of 5-year-old trees. High analysis nitrogen and potassium fertilizers were particularly effective to increase yields. For the first time in 15 years, phosphorous fertilization significantly caused larger nut kernels but the percent kernel to shell was not affected since the nuts also had heavier shells.

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WEED AND NEMATODE CONTROL

Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. Weeds compete with fruit trees for available moisture and nutrients, and this results in reduced growth and fruit yields. The losses caused by weeds can be reduced by finding more effective chemical, biological, cultural, mechanical and combination methods of weed control.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on deciduous fruits and tree nuts.

USDA AND COOPERATIVE PROGRAM

The total Federal scientific effort devoted to weed control research was 57.5 professional man-years of which 0.3 man-years was devoted to work on deciduous fruits at New Brunswick, New Jersey.

The Federal scientific effort devoted to nematode identification, physiology and control in FY 1964 totaled 19.0 professional man-years of which 0.8 was devoted to work on deciduous fruit and tree nuts at Baton Rouge, La.; Tifton, Georgia; and Logan, Utah.

PROGRAM OF STATE EXPERIMENT STATIONS

All the State experiment stations are conducting basic and applied research in weed control. These studies involve evaluation of selective herbicidal properties of new chemicals to show the relation between chemical structure, herbicidal activity and weed-crop selectivity; the nature, behavior, and effect of herbicides on their degradation products in and on plants and plant products; the mechanism of herbicidal action; influence of climate, plant morphology and soil characteristics on the effectiveness of herbicides in selectively controlling weeds and on their persistence in plant tissue. Studies are being conducted on the movement and persistence of herbicides in various soil types and the phenomena involved in absorption and other interaction of herbicides with clay complexes.

Weed life cycles and growth habits are being studied under different environments to determine the most susceptible stage of vulnerability to herbicides and other control measures. Other aspects that are currently being investigated are: competition between weeds and desired plant successions following control measures including replacement vegetation and management practices. Relation between weeds and biological control organism that attack them in different environment is being studied on a limited scale.

Much of the basic research in weed control is being done via six regional projects as follows: W-52 is exploring the fundamental biochemical and biophysical processes involved in herbicidal action; W-63 is studying the chemical and physical properties of herbicides in relation to environment and effectiveness; NE-42 is investigating weed life cycles and light as factors in weed control; NC-61 is concerned with the nature and extent of competition between weeds and crops; S-18 and NE-42 are investigating the behavior of herbicides in soil, the physiological aspects of certain herbicides and life histories of important southern and northeastern weed species. CRF-1 program is attacking basic problems in aquatic weed control and brush control. The USDA cooperates on much of this research activity.

The total State scientific effort devoted to weed control research is 344.1 professional man-years.

Nematode investigations are being conducted at most of the State Stations, and many of these scientists participate in the four Regional Research Projects concerned with phytonematology. Through these and other projects at the various institutions, scientists are contributing new knowledge on the genetics, physiology, and pathology of nemas. Some station scientists, as a result of their recent findings on nemas as vectors of viruses, are conducting intensive investigations of the biologies of this process. Other research on fundamental problems in nematology as well as work on identification and control are indicated in the appropriate crop section of this report.

The total research effort on Nematode Identification, Physiology, and Control at the State Stations is approximately 52.2 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Apples. The long-term studies begun in 1960 in New Jersey on the use of diuron, simazine, CIPC, diuron + CIPC, amitrole, plastic mulch, and clean cultivation to control weeds in apple orchards are continuing. Weed control was excellent in 1963 with all treatments except CIPC and amitrole. Analysis of trunk diameter measurements revealed no significant effects of treatments nor were yields reduced significantly.

Blueberries. Evaluation of long-term use of diuron, simazine, diuron + CIPC and diuron + DNBP in blueberry plantings in New Jersey begun in 1960 were continued in 1963. Excellent weed control was obtained in all treatments. Growth and yield of blueberry plants were unaffected by any of the herbicide treatments.

Cranberries. Growth and yields of cranberries in long-term studies of the continued use of diuron and simazine in New Jersey were unaffected after 4 consecutive years of treatments. Experiments on the control of chain fern (*Woodwardia virginica*) confirmed the effectiveness of dichlobenil on this weed although there was some reddening of cranberry vines and reduction in bloom.

Peaches. After 4 consecutive years of treatments in New Jersey with diuron, simazine, CIPC, diuron + CIPC and dalapon, marked differences in growth and yield of peaches were observed in the various treatments in 1963. It was also found that the yield and growth of peach trees in the weedy control plots were markedly reduced, indicating that peach trees are poor competitors with even low growing herbaceous weeds.

Additional long-term experiments were begun in 1962 to include amiben, diphenamid, EPTC, dichlobenil, DCPA, isocil, amitrole, and linuron. Growth was normal in all treatments in this new planting in 1963.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Fruits

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INSECT CONTROL
Entomology Research Division, ARS

Problem. Insects and mites are important limiting factors in production of high quality fruits, nuts, grapes and berries, shortening the profitable life of the trees, vines, or plants, and reducing the yield or quality of the crop. Certain insects and mites transmit diseases that adversely affect the life and productivity of the host plant. No one method of control is fully satisfactory and methods that are effective now may not be so later. At present biological, cultural and other non-chemical methods of control are only partially effective. Consequently, dependence must be placed on insecticides for control. The continued use of insecticides, however, is complicated by the occurrence of insecticide-resistant strains of an increasing number of insects and mites, by the need to avoid objectionable residues on fruits and berries and on their waste products used for livestock feed, by their detrimental effects on beneficial insects, fish and wildlife, and by contamination of non-target areas. There is a continuing need for research to develop more selective, economical and safer insecticides; and an urgent need, because of growing concern over the use of insecticides, for intensified research on alternative types of control such as those based on the use of attractants, repellents, traps, insect-resistant varieties and growth-affecting materials, including chemosterilants. More research is needed on integrated chemical-biological control programs with emphasis on less intensive spray programs, so that the maximum benefits from parasites, predators and pathogens may be realized. Research is required to determine more fully the role of insects in the transmission of important diseases affecting the production of these crops, to discover the insect and mite vectors of the diseases and to determine their host preferences, ranges, and habits. Means must then be developed to reduce or eliminate the vector populations responsible for spread of the diseases.

USDA AND COOPERATIVE PROGRAM

The Department has a long-term program involving entomologists, chemists, insect physiologists, and insect pathologists engaged in both basic studies and practical solution of growers' problems. Research on pome and stone fruit insects is carried on at Yakima and Wenatchee, Wash., Vincennes, Ind., Wooster, Ohio, Kearneysville, W. Va., and Fort Valley, Ga., in cooperation with the respective State Experiment Stations. Research on insects and mites affecting pecan production is carried on at Albany, Ga., and Shreveport, La.; on insects affecting the production of grape, blueberry and black walnut at Wooster, Ohio, in cooperation with the Ohio Experiment Station; and on strawberry insects at Beltsville, Md. Research on insects and mites in relation to the transmission of diseases of deciduous tree fruits is carried on at Riverside, Calif., Corvallis, Oreg., Wenatchee, Wash., and Fort Valley, Ga., in cooperation with the respective State experiment stations and the Crops Research Division.

The Federal scientific effort devoted to research in this area totals 21.5 professional man-years. Of this number 3.6 is devoted to basic biology and nutrition; 6.2 to insecticidal control; 2.9 to insecticide residue determinations; 0.6 to biological control; 3.6 to insect sterility, attractants, and other new approaches to control; 0.7 to evaluation of equipment for insect detection and control; 2.8 to insect vectors of plant virus diseases; and 1.1 to program leadership.

Additional research is in progress under grants of P.L. 480 funds (Projects E21-ENT-2 and 5) to the Institute of Pomology, Skierniewice, Poland, for studies of the differences in susceptibility and in cholinesterases in various species of spider mites as influenced by acaricides and for studies on the biological control of mites, aphids, and scale insects on deciduous tree fruits and effects of pesticides on natural enemies. Studies were also initiated by the Institute of Pomology, under P.L. 480 (Project E21-ENT-8) to study the mite fauna of Poland orchards with special reference to the relation between phytophagous and predaceous species. A portion of a grant of P.L. 480 funds (Project A17-ENT-5) to the Commonwealth Institute of Biological Control, Rawalpindi, Pakistan, for research on scale insects, fruit flies, and mites, and their natural enemies in West Pakistan is applicable to insects affecting deciduous tree fruits.

PROGRAM OF STATE EXPERIMENT STATIONS

A well rounded research program in this area is in progress in the States. Studies range from virus disease transmission by insects to the development of control measures involving comparisons of new insecticides. Integrated control measures are being developed in which the use of chemicals, cultural methods, natural enemies--in short, all factors which contribute to injurious insect control--are coordinated for maximum effectiveness. Schedules and new methods of application of pesticides are being evaluated to reduce residue levels and slow the development of pest resistance to these chemicals.

New techniques utilizing chemosterilants, repellents, and attractants are being investigated to determine their role in the maintenance of effective insect control programs. Light, bait and mechanical traps are being evaluated as control methods and as means of detecting the abundance of insects regularly during the season. Information obtained in such surveys provides a basis for insecticide treatment only when necessary.

All feasible methods of insect control are based on the life history and behavior of pest species. Consequently, a large part of the research effort is concerned with fundamental studies. The influences of environmental factors such as temperature, host relationships, light and other factors on development and mortality of several fruit insects are being investigated. In many instances, laboratory rearing of both pests and their natural enemies is being accomplished to accelerate the acquisition of biological information.

There are 49.3 professional man years dedicated to research in this area in the States.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Codling Moth. Large numbers of codling moth larvae and adults are needed at all seasons of the year to facilitate an uninterrupted research program. Knowledge of physical and nutritional requirements is essential to raise normal insects cheaply and in large numbers. At Vincennes, Ind., a medium was developed to rear codling moth larvae in large numbers to provide a continuous supply for use in screening insecticides, developing chemosterilants, studying diseases, and investigating chemical and sex attractants. From January 1 to June 30, 1964, more than 8,355 adults developed from larvae reared on this medium which contained apple seeds, dried apple, sugar, soybean protein, Wesson's salt, yeast, glycine, cysteine, cholesterol, alphacel, ascorbic acid, linseed oil, agar, water, potassium hydroxide, vitamin solutions, and a mold inhibitor. Ascorbic acid was essential for high yields of normal adults. At Yakima, Wash., an artificial medium composed of wheat germ, sucrose, casein, apple and agar fortified with B-vitamins, ascorbic acid, choline chloride and mineral salts was used successfully to rear codling moth larvae. Eighth-generation moths compared favorably in size with apple-reared moths and laid approximately as many viable eggs. Larvae developed at the same rate as in apples.

Biological studies showed that mature codling moth pupae floated in distilled water which permitted rapid separation of these pupae from immature pupae which sank. Differentiation of age of pupae is essential for sterilization of codling moths using either radiation or chemicals.

2. Miscellaneous Insect and Mite Pests of Deciduous Fruit. Numerous observations on biology and nutrition of deciduous fruit tree insects, other than codling moth, were made during the past year. Major emphasis was placed on the peach tree borer in Fort Valley, Ga. Only 2 field-collected peach tree borer larvae survived on variations of diets used for rearing European corn borer, corn earworm, and the pink bollworm. These larvae transformed into female moths, mated with wild males and laid eggs. Field observations at Fort Valley indicated that some of the damage attributed by growers to peach tree borer in commercial orchards was actually caused by lesser peach tree borer larvae.

In studies at Wooster, Ohio, apple maggot adults laid eggs in tiny holes punched in plastic lemons containing parts of apples or apple juice. Apple maggot larvae were reared on immature apples. Mites collected on rosetted peach trees at Fort Valley, Ga., during August and September 1963, were identified as Tetranychus schoenei.

3. Pecan and Other Nut Insects. Biological studies of nut insects at Albany, Ga., emphasized studies of factors involved in development of rearing techniques. Summer generations of hickory shuckworm moths laid an average of 50 eggs per female on nuts in cages in a screened insectary compared to only 18 eggs per female in a controlled room at 80° F. and 78% relative humidity. Fluorescent lights in the controlled room during the day and a 25-watt red lamp during the night may have prevented normal egg laying.

Efforts to rear hickory shuckworm, pecan leaf casebearer, and walnut caterpillar larvae on artificial diets were unsuccessful, possibly due to development of fungi and bacteria on the diets. Addition of sorbic acid reduced development of fungi and bacteria.

Presence of a dark spot caused by 4 glands on the dorsal side of male shuckworm larvae and newly formed pupae can be used to distinguish males from females. This differentiation is useful for biological studies of sexual behavior as well as studies of sex attractants and sterilants.

The presence of two species of plant bugs, Plagiatus repletus and Orthotylus ramus, apparently did not increase the drop of pecans. Other factors caused about 50% of nuts to shed from bloom until midsummer.

At Wooster, Ohio, eggs of the eastern walnut husk maggot, Rhagoletis suavis were laid in plastic lemons baited with unshucked black walnuts. Larvae were reared to adults on walnuts.

4. Insect Vectors of Virus Diseases. In California, no northern extension of the range of the eriophyid mite, Eriophyes insidiosus, that transmits peach mosaic, was found. No infestations have been detected in the central and northern sections of the State where the commercial production of peaches is centered. Infestations of E. insidiosus could be more easily detected on ornamental flowering peach trees in southern California than on adjacent standard varieties. This knowledge should aid in detecting the mite in new areas.

First stages of classifying the complex of related species of eriophyid mites occurring on rosaceous trees and shrubs in the Western region have been completed. The complex includes the peach mosaic virus vector originally described in this project. Other mites described in this group include a species from wild cherry, found to be a vector of cherry mottle leaf virus, a species of economic importance on pear, and 5 additional species found in associations of orchard plants.

B. Insecticidal and Cultural Control

1. Codling Moth. Development of resistance to insecticides is responsible for continual investigations of promising new insecticides for control of codling moth. In laboratory screening tests of candidate insecticides at

Yakima and Wenatchee, Wash., Bayer 42696, Bayer 50282, Geigy GS-13005 and Shell SD 9129 were the most effective materials. SD-8448 gave good control of codling moth in orchard tests. Novobiocin, an antibiotic, was 8 times as toxic as Guthion to codling moth adults. At Vincennes, Ind., approximately 65 candidate chemicals were screened as insecticides for control of codling moth, as well as control of red-banded leaf roller or two-spotted spider mite. Eleven chemicals showed promise for control of the codling moth and the leaf roller. Field studies of materials previously screened in the laboratory showed that Bayer 37344, Stauffer R-5092, American Cyanamid 47300, and Mobil MC-A-600 were effective against the codling moth but none was better than Guthion or carbaryl. Bayer 37344 was followed by severe outbreaks of woolly apple aphids at Vincennes, Ind., and Kearneysville, W. Va., when applied within 30 days of petal fall. It also reduced yield of apples.

2. Orchard Mites. Many species of mites have developed strains that are resistant to approved miticides. This situation has required an accelerated program of laboratory screening and field testing of new materials. In laboratory screening tests of candidate acaricides at Wenatchee, Wash., eight chemicals were as effective as Kelthane against both the European red mite and two-spotted spider mite, nine against the European red mite, and 17 against the two-spotted spider mite. In orchard tests at Yakima, Wash., Union Carbide 19786 and 20047 gave excellent control of the mcdaniel mite. Morestan also controlled this mite but caused spotting of 75% of the fruit. Dinocap and binapacryl were superior to Kelthane in controlling the mcdaniel mite.

Four of the 65 chemicals screened in tests at Vincennes, Ind., showed promise for control of the two-spotted spider mite. In field studies, Union Carbide 21149 was an excellent miticide, although its residue dissipated rapidly. American Cyanamid CL-47031, Morestan, and chlorbenside controlled European red mite for 50 to 60 days after petal fall when they had been applied at the pink-bud period. Two successive applications of tetradifon effectively controlled mites when used either at the pink-bud and petal-fall, or petal-fall and first-cover periods. Indopol polybutene and Foxlene formulations have consistently caused excessive phytotoxicity although they gave good mite control. Seven miticides, Union Carbide 21149, American Cyanamid E.I.-38906, chloropropylate, Kelthane, Morestan, binapacryl, and chlorobenzilate, applied to apples on July 10 and 17, gave control of European and two-spotted spider mites for 28 days following the second application at Vincennes. Morestan and chlorobenzilate were slightly phytotoxic to apples. The most promising new miticides field tested in the spring of 1964 included Union Carbide 20047A, UC 19786 and Morestan. Morestan caused phytotoxicity at Vincennes, and at Kearneysville, W. Va., in post-bloom cover sprays.

3. Plum Curculio. New insecticides that are safe to handle and can be used throughout the year are needed for control of plum curculio. Parathion and Guthion are hazardous to handle and dieldrin can be used only in the

early part of the season. At Fort Valley, Ga., five applications of Bayer 37344, Bidrin, or Imidan gave better control of plum curculio in peaches than did parathion in an orchard experiment. Bidrin caused light to moderate defoliation following the second application. UC 22708 exhibited considerable synergistic action when used with carbaryl at a 15 to 1 ratio against the adult curculio. Under simulated field conditions, aldrin continued to be very effective during the 12th season for the control of immature stages of the plum curculio.

4. Pear Psylla. Increased emphasis has been given to control of this pest because of its resistance to summer spray treatments and its possible relation to spread of pear decline on the west coast. In laboratory screening tests, Bayer 34735, Shell SD-8436, and Shell SD-8949 were as effective as Guthion against pear psylla. Morestan and Superior oils (57, 70, and 140 viscosity) were effective in delayed dormant sprays and Perthane in a cluster bud spray in orchard tests against pear psylla at Wenatchee. Better control was achieved when the pear trees were sprayed in the delayed dormant stage rather than the cluster bud stage. In field tests of eleven insecticides at Yakima, Wash., excellent control of pear psylla was obtained from three applications of Farbwerke Hoechst 2813 or Union Carbide 21149. Volck supreme oil alone or with Guthion, and Bayer 37344, were more effective than Guthion as summer sprays against pear psylla. Imidan, Perthane, and Union Carbide 20047 gave good control but had shorter residual effectiveness.

5. Insect Vectors of Virus Diseases. Studies on insecticides for control of the vector of peach mosaic virus in an isolated district in San Bernardino County, Calif., were continued for the fourth season. Insecticides have been applied each year since 1961. Diazinon was applied, as a petal fall spray, to all peach plantings in the district for control of E. insidiosus, the vector of peach mosaic virus. New infestations of mosaic were found in 3% of the trees in 1960, 5.8% in 1961, 10.5% in 1962, 4.7% in 1963, and 0.4% in 1964. The reduction in new infections since 1962 shows that control of this species of mite is resulting in a reduction in transmission of the disease.

At Fort Valley, Ga., applications of 10% granular Bayer 25141 were effective in controlling one vector of phony peach disease, Cuerna costalis, when 30 to 50 gm. were applied around the base of young peach trees. Foliar sprays of eleven insecticides were ineffective in controlling C. costalis or Homalodisca coagulata.

6. Miscellaneous Insect Pests of Deciduous Tree Fruit. Experiments to control many insect pests must be coordinated with sporadic infestations of these pests. One such species is the periodical cicada. Brood 23 of this insect is a pest in Indiana. Treatment of wooded areas surrounding orchards, as well as the apple and peach orchards, with carbaryl sprays would be desirable to control adult periodical cicada during the pre-oviposition period. Laboratory and field investigations at Vincennes

showed that Union Carbide 21149 and Zectran were more effective than carbaryl, Bayer 37344 or Mobil MC-A-600. Trees that had severe decline from nymphs feeding on their roots showed good recovery the second and third year after either phorate or carbaryl was injected into the soil in the root zone. Cooperative tests with the Ohio Agricultural Experiment Station at Wooster showed phorate was more effective than carbaryl for killing the nymphs.

At Vincennes, good control of San Jose scale was secured with Guthion, parathion, carbaryl, and Bayer 37344, applied in cover sprays at the time crawlers are active. Oil-ethion applied during the prebloom stage was no more effective than insecticides used in the postbloom sprays. Malathion and DDT, used in the cover sprays, did not maintain satisfactory control.

In laboratory screening tests at Wenatchee, Stauffer B-9564 was as effective as parathion against both apple and green peach aphids. Three other candidate insecticides tested against apple aphids and 19 against green peach aphids were as effective as parathion. Green peach aphids, apple aphids, and woolly apple aphids were controlled by injections of dimethoate in the trunks of apple trees.

In Georgia, four oil emulsions, Orchex 780, 796, 1080, and N-790, reduced the population of white peach scale infesting young peach trees. Bidrin was ineffective in late season applications against this pest.

Extensive experiments in Indiana, to develop a more economical spray program for apple pests, showed that mite control should start in the pre-bloom period, using oil, Morestan or chlorbenside, or two applications of tetradifon. An early aphicide such as benzene hexachloride or demeton was generally needed to control rosy aphid. Guthion was the most practical insecticide for use at or within 30 days after petal fall, since it controlled codling moth, red-banded leaf roller, scale, and plum curculio, and did not russet fruit. A combination of Guthion plus carbaryl in the late cover sprays gave adequate control of insects on apples in July and August. The study showed that most growers were applying too many treatments, with 5 to 7 cover sprays generally being adequate. At least three post-bloom applications of miticides were needed to control mites.

7. Berry Insects. At Beltsville, Md., in strawberry field plots, spider mites resistant to insecticides could not be satisfactorily controlled by fall sprays and early spring sprays because the mites were protected by host leaves lying on the ground. Later spring sprays of tetradifon-Kelthane mixtures resulted in effective control on upstanding foliage. Spring applications of granular phorate, Bidrin, Di-Syston and Meta Systox-R at 4 and 8 lb./acre also were effective against spider mites on strawberries.

At Wooster, Ohio, a combination of carbaryl and malathion, applied to blueberries after bloom, practically eliminated a heavy infestation of cherry

fruit worm and blueberry tip borer.

8. Pecan and Other Nut Insects. In studies of chemicals to control the pecan leaf casebearer, four applications between May 1 and July 19 of dodine, a fungicide, gave nearly complete control of this insect. Dodine had been used for control of scab in conjunction with an insecticide spray program using a July application of malathion, parathion, carbaryl, Guthion, or EPN. A February application of parathion gave better control of dormant larval stages of the casebearer than DN-289, Guthion, zineb, or dodine. Applications of 2, 4, or 8X concentrate sprays of EPN were as effective as dilute sprays in controlling pecan weevil. Soil application of granular Di-Syston (1 lb./acre) failed to control black pecan aphid and a yellow aphid Monellia nigropunctata on small potted pecan trees.

9. Insecticide Resistance. In continued research in Poland under P.L. 480 Project E21-ENT-5 for phosphorus insecticide resistance in the two-spotted spider mite, no resistant strains have been found and attempts to develop them in the laboratory have not been successful. However, strains of the European red mite resistant to methyl parathion, trichlorfon, and malathion have been found.

C. Insecticide Residue Determinations

1. Residues in Plant Parts. The amount of residues on or in fruit or foliage following insecticide applications was determined by chemists at Beltsville, Md., Yakima, Wash., or Vincennes, Ind. Residues of 8.7 ppm of Guthion on Washington pears at harvest were reduced 95% by 14 days storage followed by washing with a detergent, before canning. Residues at harvest of 1.0 to 66.7 ppm of polyolefin were found on apples from Indiana orchards treated in May with polypropene or polybutenes for mite control. Treatment in July left residues of 47.7 to 199.3 ppm on apples at harvest. At Vincennes, apples sprayed with binapacryl 21 days and 1 day before harvest averaged 0.5 and 1.7 ppm, respectively, at harvest. MC-A-600 present on harvested apples was 3.3 ppm when the interval between treatment and harvest was one day and 1.3 ppm when the interval was 21 days.

Samples of grape juice from growers' vineyards in Ohio had no trace of DDT, methoxychlor, captan, or parathion. Soil application of phorate resulted in from 3.0 to 18.6 ppm of phorate in grape foliage but less than 0.1 ppm in the fruit.

2. Residues in Soils. Applications of insecticides to foliage, as well as to soil, result in insecticide residues in the soil. Soils from 35 randomly selected southern Indiana apple orchards contained from 21 to 2,100 ppm of DDT, mostly in the upper 2 inches of soil. Samples of soil from Indiana peach orchards treated for 4 seasons with benzene hexachloride or endrin sprays applied to the ground under the trees contained 0.3 ppm benzene hexachloride and 1.1 to 1.9 ppm endrin. Soil between the trees contained less than 0.1 ppm of insecticide.

Samples of soil in Ohio, two years after soil applications of granular dieldrin for control of apple maggot or walnut husk fly, contained 7.1 to 15.2 ppm of dieldrin. Similar samples, two years after treatment with aldrin, contained up to 0.4 ppm aldrin and from 0.12 to 0.65 ppm dieldrin.

D. Biological Control

1. Codling Moth. In West Virginia, use of DD-136 nematode to control codling moth in an isolated orchard was discontinued after 4 years, since little or no decrease in codling moth injury was obtained between this orchard and untreated orchards. At the time the experiment was discontinued, 15% of the overwintering larvae were parasitized by *Ascogaster*, 4% were infected by nematodes and 4% by fungus. San Jose scale had built up during the past 4 years to a heavy infestation.

2. Aphids and Scale Insects. Research in Poland under P.L. 480 Project E21-ENT-2 showed that natural enemies of the European fruit lecanium scale, *Lecanium corni*, was more severely affected by dormant sprays than by spring sprays. In studies on lacewing fly predators of aphids, it was found that a single larva of *Chrysopa* sp. will destroy 100 to 521 aphids before maturity. The female of *Chrysopa* required honeydew in its diet for egg laying but produced most eggs when fed both aphids and honeydew.

E. Insect Sterility, Attractants and Other New Approaches to Control

1. Codling Moth. Intensive studies were undertaken on sterilization of codling moths by radiation or chemicals as a means of control at Yakima, Wash. In laboratory studies of radiation, exposure of male codling moths to 20, 30, 40, or 50 kiloroentgens (Kr) gave 78, 85, 96 and 99.6% reduction in egg hatch when crossed with untreated females. Exposure of fully developed pupae to 15, 20, 30, or 40 Kr gave 40, 75, 86, and 96.5% reduction in egg hatch when treated male moths were crossed with untreated female moths. Female moths irradiated as adults or fully developed pupae at 20 Kr produced no viable eggs. Similar results were obtained when adult moths were irradiated with X-rays. High mortality of pupae occurred after exposure of 4-day old eggs to 5 Kr or mature larvae to 10 Kr.

In laboratory studies of chemosterilants, topical application of 30 micrograms of tepa to adult moths resulted in a 99% egg sterility with no reduction in longevity or mating. Treatment of mature larvae with 30 micrograms of tepa per insect induced high larval mortality, caused larvae to hibernate, and surviving moths in many cases were deformed. Dipping 4-day old eggs for 1 minute in 5% tepa gave 87% egg mortality. No sterilization effects were noted when pupae were dipped in 5% tepa for 1 minute. Dipping adult moths for 10 seconds in 2% tepa prevented hatch of eggs when they were mated with untreated moths.

Field-cage tests resulted in a reduction of 84% in the F_1 generation when 40 male codling moths irradiated at 40 Kr were released for every untreated

female moth, compared with a 6-fold increase in infestation from populations of untreated moths. Similar results were obtained using moths treated with tepa.

A sex lure obtained from female codling moths initially was more attractive than bait or light traps. The sex lure attracted as many moths as the bait or light traps after 5 to 10 days exposure. Only males were attracted to the sex lure, while moths of both sexes responded to the traps.

Light traps were 60% more efficient than bait traps for codling moth surveys. Sixty percent of moths caught in light traps and 50% from bait traps were males. Lights attracted younger moths than baits. Dissection of female moths collected in light or bait traps showed that 40% had mated once, 18% twice, 10% three times, and 24% four or more times. Eight percent had not mated when trapped.

2. Plum Curculio. In Georgia, dips containing 2% tepa or tretamine sterilized plum curculio adults. Larvae treated with 0.25% tepa failed to emerge as adults. Six experimental sterilants did not show sufficient effect to warrant further testing.

3. Fruit Tree Borers. Studies at Vincennes, Ind., showed that male lesser peach tree borer moths were attracted to a substance given off by virgin females. Fifty-nine percent of the females used in field tests were attractive to the males, with an average of 23 males per female trap. The attractive substance may be removed to cotton by rubbing or to alcohol by maceration. Twenty-six percent of marked male moths released $2\frac{1}{4}$ miles from an orchard containing 30 female attractant traps were recaptured.

In Georgia thirty male peach tree borer moths were captured in a trap containing a single virgin female within a short time and approximately 100 males were observed flying around the trap. Methylene chloride extracts of the tips of female abdomens were less attractive than live females but more attractive than either benzene or alcohol extracts. Extracts from crushed or uncrushed abdomens were equally attractive.

4. Nut Insects. Investigations at Albany, Georgia, showed that a 15-watt blacklight trap was effective in attracting adult hickory shuckworm (1786 between March 23 and June 10), pecan nut casebearer (350 between May 2 and June 8), and pecan leaf casebearer (7942 between May 21 and June 30). Approximately 55% of the shuckworm and leaf casebearers and 50% of the nut casebearers captured were females.

F. Evaluation of Equipment for Insect Detection and Control

1. Fruit and Nut Insect Control Equipment. Comparisons of different types of sprayers and spraying techniques at Wooster, Ohio, did not show significant differences in spray residues deposited on grape leaves or fruit. In Louisiana, aerial applications of 1 pound actual parathion, 1 lb. ethion,

or $\frac{1}{4}$ lb. demeton in 5 gallons of spray per acre or $1\frac{3}{4}$ lb. malathion in 6 gallons per acre gave control of the mite Eotetranychus hicoriae. An aerial application of parathion gave 99% control of fall webworm larvae.

G. Insect Vectors of Diseases

1. Miscellaneous Stone Fruit Virus Diseases. At Corvallis, Oreg., transmission of a new virus disease of cherry by the pea aphid, as well as the green peach aphid, was demonstrated. At Wenatchee, Wash., studies were initiated to determine if a leafhopper, Colladonus geminatus, a nematode, or 2 species of aphids, green apple aphid and woolly apple aphid, were vectors of apple mosaic or green crinkle virus diseases. Sufficient time has not elapsed for symptom development. Results of 77 transmission tests, initiated in Georgia in 1963, to discover the vector of peach rosette virus disease, as well as tests maintained from previous years, were negative.

2. Pear Decline. Work at Riverside, Calif., culminated in strong evidence that pear psylla will inject toxins capable of producing tree damage, that this damage is acute only when high populations of psylla are present, and that trees usually recover from the effects of the toxin when psylla populations are reduced. In contrast, trees that have the pear decline disorder do not recover but progress into either the wilt and death phase or the chronic decline phase. Results of transfers of pear psylla in vector-test experiments indicate that a causal virus has been transmitted.

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PEST CONTROL TECHNIQUES AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. Many pests attack economic crops in the United States, resulting in billions of dollars of loss to the farmer each year. Plant diseases, weeds, insects, and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment. Effectiveness of the equipment necessary may be essential to the success of the method which is attempted or recommended.

Thus, equipment to control a wide variety of pests on a wide variety of crops is required. This requirement is partially met by the sprayers, cultivators, dusters, and soil injection equipment now available. However, mechanical cultivation does not always produce satisfactory weed control, and it is time consuming and costly. It is believed that with sprayers and dusters now used, often no more than 10 to 20 percent of the chemical goes onto the plant. Methods of applying nematocides in the soil do not always result in uniform nematode control, and untreated soil below the treated zone, in untreated pockets, and at the soil surface, provide sources for quick reinfestation.

There is need for improved methods of much greater efficiency for applying pesticides to plants and the soil. This implies a need for considerable fundamental study of small particle behavior, of radically new methods of applying chemicals, and of the movement of liquid and gaseous chemicals in the soil. The sales of present equipment are not great enough, nor are the manufacturers large enough, to permit industry to make a very great investment for research in this field.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers' problems. Cooperation is with the State Agricultural Experiment Stations of the States mentioned, unless otherwise noted. At Wooster, Ohio, basic research is conducted on fundamental studies of aerosols and on various spray formation devices. Soil fumigation research also is conducted at Wooster, Ohio. Disease control research is also conducted at Wooster, Ohio. Pest control equipment research for certain crops is conducted: for cotton at Auburn, Alabama, Stoneville, Mississippi, Shafter, California, Lubbock, Texas, and (particularly for boll weevil control) at State College, Mississippi; for vegetable crops at Forest Grove, Oregon, and for brush control at Mayaguez, Puerto Rico, and College Station, Texas.

The Federal scientific effort devoted to research in this area totals 14.4 professional man-years of which 1.7 is devoted to basic studies in aerosols and spray formations, 1.0 to soil fumigation, 1.0 to insect and disease

control by ground equipment in vegetables and other low-growing crops and 0.9 to aircraft equipment for application of pesticides to vegetables and other low-growing crops; and 1.0 to aerial spray equipment for forest insect control.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2.7 man-years is devoted to this work on all crops; figures are not available for work on deciduous fruit and tree nuts.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Studies in Aerosols and Spray Formation.

1. Mathematical and experimental studies on the basic transport, spreading, and distribution processes for fine particles suspended in turbulent gases were continued at the Pioneering Research Laboratory on Physics of Fine Particles at Wooster, Ohio. An instrumentation system is under development for measuring the distribution of fluorescent-traced particles on deposition surfaces to facilitate the study of relations between deposit distribution and the turbulence producing it. A method of spectral analysis has been developed which appears to be applicable to the measurement of surface deposit, but which needs further study. The use of a tape recorder has made experimental procedure immeasurably easier than if one attempted to process the "live" signal directly. Additional work is being carried forward in the areas of heat and moisture diffusion in fine-particle starch doughs, and in electrical diffusion of clay suspensions.

B. Soil Fumigation.

1. Field treatments were made in cooperation with the Ohio Station in order to study and develop methods and equipment for applying chemicals to soil for the control of crop pests. A number of volatile materials are now available in pressurized cylinders or bottles similar to the containers used for oxygen, nitrogen and other compressed gases. By using an appropriate regulator, these materials are easily applied by the field cultivator equipment with injector blades. Applications of this type made for control of Verticillium in vegetable plantings gave substantial increases in yield but the materials do not give the desired control of this disease. Measurements made of cherry trees planted in soil treated with several different nematocides in 1957 and 1960 show increased twig growth and greater spread of branches than in untreated plantings.

Applications of herbicides by a rotary tiller type of applicator, operated with forward travel per blade cut ranging from 1.5 to 4.7 in., show best result with the short cut. The short cut is believed to give a better resultant mixing of non-volatile chemicals with the soil.

Latex, asphalt and wax emulsions were applied to soil as surface mulches. This had previously been found to increase plant growth including weeds. Several formulations including different herbicides were applied. Generally these formulations appeared to produce some seedling injury and reduction in stand in vegetables on which they were used.

C. Insect and Disease Control by Ground Equipment in Vegetables and Other Low-growing Crops.

1. Both hydraulic and air blast sprays were applied to sugar beets in cooperation with the Ohio Station and Northern Ohio Sugar Company. Hydraulic applications were designed to study seasonal timing of spray applications, effect of interval between applications, various copper and oil combinations, and control achieved by other fungicides. Results were obscured by dry weather which prevented disease development. For example, although seven sprays of a copper and oil fungicide, beginning July 16 and applied at 10-day intervals, gave the best disease control, the yield of beets and sugar was no better than five sprays applied at 15-day intervals or three sprays at 20-day intervals.

A series of seven different air blast sprays were applied to sugar beets at 10-day intervals. Variations included gallonage applied, swath width, fungicide used, and operating pressure. Dry weather permitted little development of *Cercospora* leaf spot infection in the beet foliage. All treatments, therefore, gave excellent control of this disease. Manzate and copper with oil applied at comparative rates, showed a slightly higher sugar yield in favor of the former. Copper analyses were made of deposit samples taken across a 100-ft. double swath sprayed from both sides. These show a higher center deposit at a 40 gal. per acre application rate, when compared to rates of 20 and 10 gal. per acre. Other sample analyses show deposit patterns are affected by size, number, and placement of nozzles and by wind velocity and direction.

Sprays were applied to sugar beets at another location to study the effect of supplemental oils in improving the fungicidal action of fixed-coppers. The experiments indicate that increasing quantity added or viscosity of the oil, within the limits studied, increased the adhesion of copper to this foliage.

Sprays were also applied to a mixed vegetable planting to study spray adhesion on various types of foliage (pubescent or glabrous). The effect of dew and rainfall was included in this study, but extreme dry weather interfered with this part of the experiment. The results suggest that smooth foliage should be sprayed more frequently and with a higher dosage than hairy foliage, to obtain comparable disease control.

D. Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-growing Crops.

1. Major project activities in 1963 included the rebuilding of a Bell 47D1 helicopter which was obtained by transfer in 1962. Operations consisted of dismantling all major components, sandblasting, overhauling, inspecting for flaws, painting and rebuilding the entire unit. Spray equipment was designed, fabricated and fitted to the helicopter and will be used in the research investigations. In February and March of 1963, an aircraft mechanic and machinist, and an aircraft pilot, attended schools for helicopter mechanics and pilot training, respectively.

A series of bait insecticidal sprays were applied with the Rawdon T-1 airplane to a crop of peas for the control of the pea weevil in canning peas. These applications were made near Woodburn, Oregon, in cooperation with the Entomology Research Division. The flight elevation was about 25 ft. and the swath spacing 50 ft. The bait sprays consisted of brown sugar mixed in water and endosulfan or malathion and applied at the rate of 4 gal. of formulation per acre. The object of the tests was to control the insect with a minimum amount of toxicant by use of an attractant bait. In one test area the results were inconclusive. In another area 84 to 93 percent control was obtained at 48 hrs. after the application. The tests showed that the bait spray will suppress the pea weevil population on canning peas although not 100 percent was obtained.

Assistance was given to the Forest Service in conducting exploratory spray distribution tests with a helicopter owned and operated by Evergreen Helicopters of McMinnville, Oregon. The results of these pattern studies were used by the Forest Service as a basis for a series of aerial pesticide application tests with helicopters to control the Western Hemlock looper in Pacific County, Washington.

A spray distribution test series was conducted in cooperation with the Piper Aircraft Corporation using a Piper Pawnee PA-25-235 furnished by the Company. These data showed that a reasonably uniform and satisfactory deposit pattern as well as swath width could be obtained with a low density application rate (1-3 gal. per acre) when an asymmetrical nozzle arrangement was used. A satisfactory deposit pattern was not obtained for the high density applications. Tests were discontinued when the aircraft was recalled by the Corporation because of other commitments. These high density tests will be continued as opportunity permits.

A limited number of tests were conducted with a Piper Pawnee PA-25-235 aircraft owned by Sam Whitney of Newberg, Oregon. This aircraft was equipped with a hydraulically driven spray pump instead of the externally mounted windmill type drive and external mounting used by Piper Aircraft. The change in pump mounting did not appear to affect the spray pattern being deposited.

E. Aerial Spray Equipment for Forest Insect Control.

1. Since a helicopter was not readily available at Beltsville, some spray studies were made in cooperation with the Forest Service, using a PA18A fixed wing airplane at 45 to 50 m.p.h. to simulate helicopter application. The degree of spray atomization is an important factor affecting the distribution and effectiveness of aerial sprays. There is considerable information on the atomization produced by various nozzles on fixed wing aircraft but for helicopters such information is very limited. Two flat spray pattern nozzles, T8004 and T8006 (Spraying Systems Co.) with flow rates of 0.4 and 0.6 g.p.m. were used with the orifice directed forward and down about 40 degrees to the thrust line of the plane. The atomization was 176 microns mmd from the former and 179 from the latter - no significant difference. About this same atomization (180 microns mmd) was produced by a hollow-cone nozzle, D4-25, with an output of 0.29 g.p.m. The orifice was also directed forward and down 40 degrees. Thus, for this atomization of 176 to 180 microns, the flat spray nozzles would be preferable to the hollow cone nozzles because a smaller number of them would be required to provide a given output.

On the studies with heavy aircraft a series of flights were made with a TBM airplane at 200-ft. altitude to study spray distribution from this height as compared to that from lower heights (100 to 150 ft.). Flow rate of the plane was 107 g.p.m. for an application of 1 g.p.a. over a 300-ft. swath at 170 m.p.h. Based on a total of 20 flights, 10 at each height, there was no difference between the two heights at the 0.25 g.p.a. deposit level. At deposit levels of 0.1 and 0.2 g.p.a. swath width was slightly greater at the 200-ft. height but the reverse was true at deposit levels greater than 0.25 g.p.a. These tests showed that the present recommendations of a 300-ft. swath for a TBM will result in a deposit of not less than about 0.15 g.p.a. over this width. Considering overlap of adjacent swaths, deposit should be adequate for control of most forest defoliators. The average spray recovery was 73 percent.

A pilot test of an aerial application of B. thuringiensis, a biotic insecticide, was carried out for control of the gypsy moth in New York State. A Piper PA18A was used to apply 2 gal. per acre using a 75-ft. swath width. A one percent concentration of a water soluble fluorescent tracer, Laucophor C 6202 (Sandoz Chemical Works) was added to the spray mix. Samples of the spray were collected on white Kromekote cards placed in the plots. After spraying, the cards were irradiated with ultraviolet light. The tracer was found to be a very good indicator of spray deposit. The application reduced gypsy moth populations but did not effect acceptable control. No further large scale field applications of this material will be made until additional laboratory work is done to improve its toxicity.

The development of methods for measurement of spray deposit by use of fluorescent tracers has been continued. Attempts are being made to quantitatively assess spray deposits on paper cards. Position and intensity

of ultraviolet excitation source has been studied and an enclosure constructed in which sprayed card samples can be assessed. Calibration work is in progress. The measurement of water sprays either by fluorescent tracer or estimation from dyed card standards is an important problem to be investigated during the coming year.

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CROP HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting and farm handling crops, with emphasis on the preservation of inherent qualities during these processes. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Research on deciduous fruit harvesting equipment at East Lansing, Michigan; Wenatchee, Washington; and Davis, California is cooperative with the Experiment Stations in those States, and with producers, and machinery manufacturers. Crops under study include apples, pears, peaches, apricots, plums, grapes, blueberries, cherries, and dates.

The Federal engineering effort devoted to research in this area totals 29.0 professional man-years, of which 5.5 is on deciduous fruit.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 44.2 professional man-years is devoted to this work on all crops; figures are not available for work on deciduous fruits.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

1. Handling Grapes. About 225,000 tons of Concord grapes are produced each year in the six States of New York, Michigan, Washington, Pennsylvania, Arkansas, and Ohio. Conventional harvesting and handling methods are expensive and cause considerable damage to the raw product. A report was published on the development of a machine for picking up field boxes of grapes. Both Bacos and Concord varieties of grapes were picked in half-bushel baskets and transferred in the vineyard to pallet boxes holding approximately 850 pounds each. The study showed that quality was maintained and that \$2 per ton was saved in handling labor. Also, there were substantial savings in container costs and congestion was eliminated at the processing plant. A report on this work is being prepared.
2. Harvesting Clingstone Peaches and Apricots. It is predicted by many experts that hand labor for harvesting tender flesh fruits will not be available in the near future. Previous research showed that mechanical shakers were feasible, provided yields and quality could be maintained. Four acres each of two varieties were harvested mechanically by research personnel

and five commercial blocks were harvested by growers using commercial equipment. Data were obtained on yields, fresh fruit quality, canning grades, and harvesting rates and costs and compared to checks harvested by hand. In orchard No. 1, 97 percent was recovered by hand harvest compared to 86 percent by machine harvest. When fruit damage was included, 91 percent was graded No. 1 fruit for hand harvest, whereas 75 percent was graded No. 1 for machine. In orchard No. 2, 94 percent and 88 percent were recovered by hand and machine, respectively. Eighty-two and 74 percent were graded No. 1 by hand and machine. A large part of the difference in the amount of recovered fruit was primarily due to fruit left in the tree. More fruit was bruised by hand picking than by machine, indicating that the padding and decelerator strips did an effective job. However, this was more than offset by the greater number of cuts in machine harvest resulting from fruit falling through the tree. Modifications in tree training and pruning may minimize this damage. Cost per ton of No. 1 fruit for hand harvest was calculated to be \$11.05, whereas cost per ton for machine harvest for yields of 10, 15 and 20 tons per acre were \$11.45, \$7.65 and \$5.70, respectively. If the equipment is used on a two-shift basis, corresponding costs would be \$8.80, \$5.85 and \$4.40. Adding the loss of fruit of 5 and 10 percent for a 15 ton per acre yield, the cost would be \$10.15 and \$12.65.

3. Mechanical thinning of peaches. Hand-thinning of peaches and apples is expensive and labor consuming. Chemical thinning of peaches and early variety apples is considered impractical by most growers because of the inconsistency of the results. Tree shakers are now available for harvesting some fruit and they can be used for thinning. Michigan peach growers thinned approximately 500 acres of peaches with machines in 1963. The savings, in many cases, amounted to \$50 per acre. Studies showed that there was no significant reduction in yield when machine-thinned trees are compared to hand-thinned trees. Another study showed that cumulative bark damage, up to this point at least, has not been serious. This project is being closed out.

4. Apples bruise easily and must be handled with care when harvested for fresh market. This type of picking is difficult, time consuming, and it is becoming difficult to recruit labor. Techniques and machines which will make it easier and less costly to harvest apples for fresh market are needed. In Washington, a fruit conveying mechanism was developed for attachment to a commercial self-propelled tree "working" machine. With the aid of the machine and its attachment, the picker can position himself at the optimum picking location, remove the fruit and place it in the waist level receiving trough for delivery to the bulk bin and subsequent distribution within the bin. Increased picking efficiency was obtained and comparative time studies showed that picking Red Delicious and Winesap apples from the machine yielded increases of 18.4 and 34.7 percent, respectively, over the ladder picking rate. Bruise damage obtained with the experimental conveying system was compared to that received in the conventional ladder and bag system. Increases of 4.0 and 15.5 percent were obtained in Red and Golden Delicious varieties, respectively. Drop tests indicated that a

decelerating medium consisting of a one-inch thick mat of open cell poly-ether foam, covered with a 2-1/4 inches of water, could be used to collect free falling apples. No bruising of fruit occurred when using this combination to stop Golden Delicious apples falling 16.5 feet.

5. Over 35 percent of the apples produced in the United States are now processed. Growers only receive 80 cents to \$1 per bushel for apples and profits are small. Present picking costs of 20 to 25 cents per bushel need to be reduced. In Michigan, an experimental catching frame which would collect (with a minimum of bruising) apples harvested with tree shakers was constructed. In September 1963, five 24-bushel bulk boxes of McIntosh apples were harvested with an inertia shaker and catching frame. On October 17, four bulk boxes of Northern Spys were machine picked. These apples, along with hand-picked check lots, were trucked more than 100 miles to a CA storage and held until April 4, 1964. McIntosh and Spys are both tender varieties and the over-six-month storage resulted in a severe test. The McIntosh apples were graded and packed into three-pound poly bags on April 13. The mechanically-harvested McIntosh apples resulted in a 32 percent less pack out than the hand-picked fruit. However, almost all of the apples that did not make number one grade were suitable for processing. Next year similar studies will be made with the exception that some of the apples will be processed immediately and the rest processed after a three-month storage period. In Washington, a limited shake test was made on Red Delicious apples to determine the type of fruit separation which might be expected with shake harvesting. Separation acceptable for fresh market fruits was obtained in 65 percent of the manually shaken sample. Construction of a mechanical inertia shaker for further experimental work in this area is underway. The above tests indicate the possibilities of harvesting apples for processing outlets and also for fresh market outlets when labor is very critical.

6. Standard apple tree shape and size is about as ineffective for mechanized harvesting as could be designed. The tree walls of standard trees planted 12 feet apart in a row and the rows 18 feet apart were over 6 years old and yielded over 600 bushels per acre. Time and motion studies of picking will be made during next harvest and compared with picking conventional trees. The apple and peach trees were hedged for the third straight year and no significant yield differences were obtained.

7. Cultivated blueberries are grown commercially in the Mid-Atlantic States, Great Lakes area, and the Pacific Northwest. Although this project has developed equipment and methods which greatly reduce the cost of harvesting and packing blueberries, costs are still rather high. A continuous-type blueberry harvester should reduce picking costs even further. The experimental unit for testing a principle of continuously harvesting blueberries mechanically was constructed and field tested. The results indicate that as far as fruit removal is concerned, the machine is satisfactory. Considerable time and effort will be required to perfect a prototype machine, however.

8. From one-third to one-half of the gross returns of both sweet and sour cherries are paid to the workers who harvest the crop by hand. These workers are becoming increasingly hard to recruit; a situation which exists in all cherry-producing areas. The purpose of the research is to reduce the harvest costs and labor requirements through mechanization and at the same time maintain quality of the fruit. Multi-purpose fruit bulk boxes were tested with cherries and peaches. These boxes, which contained hinged, horizontal partitions, can be used effectively on soft fruits which cannot be handled at depths of more than 8 inches in conventional or shallow bulk boxes. Sweet cherries were again handled successfully in bulk boxes at depths of 16 inches for brine outlets and 14 inches for canning outlets. A report of this work was published. Electric sorting machines used for the first time were evaluated. A report was made available. With improvements they should reduce the number of workers needed and also reduce costs. Last year the units cost the processors about \$1 a ton more than hand sorting. They proved effective in removing decay and scald defects but did not remove stems or light cherries. Design data on construction of destemmers for tart cherries was obtained by evaluating commercial destemming units for sweet cherries. A tart cherry destemmer has been designed and is under construction and will be tested next summer. The studies on cushioning materials and terminal velocities were completed and separate reports prepared for publication. Urethane foam is a good all-around cushioning material. A hydrocooler for cherries has been designed and is being constructed. It has a theoretical capacity for reducing the temperature of two tons of cherries from 80° to 32° F. per hour. It will be used to hydrocool over 50 tons of tart cherries.

9. Harvesting prunes. Although research on this project has led to the adoption of mechanical harvesting in the Sacramento Valley, prunes are still harvested by hand in the Santa Clara Valley where prunes fall to the ground as they mature over a month period. Work on this project during 1963 concentrated on the evaluation of the use of pickup machines. Tests were conducted on two soil types--loam and gravelly loam. The orchards were only rolled but the use of a landplane operation is advised and would have eliminated some fruit loss and dirt and clod pickup. Results show that prunes can be picked at an average of 60 trees per hour, assuming four passes per tree. A yield of two-thirds box per tree resulted in 40 boxes per hour. Lug box handling required two men for the pickup operation and one man to operate the shaker for an output of 13 boxes per man-hour. Bulk handling would reduce the crew size to two men, resulting in an output of 20 boxes per man-hour. A pickup machine operation appears to be the harvest method with the least risk. Although the pickup method is not the ideal solution, its use involves fewer potential problems than either the shaker and catch frame or the pulsating air methods. The major drawback of this lower risk operation is the land preparation which must be done carefully for successful harvest.

10. Bark damage can be a serious problem when tree shakers are used to harvest or thin fruit. In California, research initiated in 1962 was continued. This included a study of the forces developed while shaking various size limbs, the maximum stresses that cause bark injury, and possible methods of attachment for shaking that would not exceed these allowable stresses. No appreciable difference was observed in the effect of contact area on the stress causing browning at the cambium. This occurs in the range of 575 to 600 p.s.i. Results on the effect of limb size show that the stress exerted on a small limb is substantially greater than on large limbs. The reason for this is that the area of contact is reduced in greater proportion than is the total force exerted from large (5-1/2 inch) to small (1-1/2 inch) limbs. The 1963 belt-type clamp was modified to improve pad stability by relocating the pivot point to an effective location where the belts contact the limb. In tests it was found that when the shaker axis was 25° to 30° away from perpendicular to the limb, the bark was sheared in a longitudinal dimension. (This problem was not encountered in 1962--the pads were unstable at these angles and it was not possible to conduct this test.) No damage occurred either radially or tangentially. In analyzing the problem it was found that when a tight grip is made on the limb the longitudinal force component exceeds the yield strength of the bark and failure occurs. If only a snug grip is made, the belts can move relative to the bark and only scuffing of the bark occurs. This is not a practical solution since variation in bark smoothness would require different clamping pressures. A number of possibilities are now being considered for future work on this project. In Michigan, a new type C-clamp for tree shakers, having five prongs on each face, was designed and constructed. The prongs will penetrate into the heart wood as the clamp is closed. The clamp will not slip or tear the bark. It will, however, puncture the bark in ten places and the significance of this type of damage will have to be evaluated.

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II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

UTILIZATION RESEARCH AND DEVELOPMENT

APPLES AND OTHER FRUITS -- PROCESSING AND PRODUCTS

Eastern Utilization Research and Development Division, ARS

Problem. Lack of knowledge of the nature and quantities of the various chemical constituents and enzyme systems present in fresh fruits, and of the changes these undergo during processing, is a limiting factor in research designed to develop new and improved products and processing techniques. Knowledge is required on the composition and physical structure of fruits and fruit products, with emphasis on substances responsible for color and flavor, vitamins, and other constituents important in determining consumer acceptance and nutritive value of the products. Composition should be studied in relation to variety, stage of maturity, and environmental conditions of growth; and to changes occurring between harvesting and processing, during processing, and in storage and distribution. Recently-developed equipment and techniques have made it possible to isolate, separate, and identify constituents that could not have been handled previously. As basic information is developed, new processing techniques will be applied in the improvement of fruit products, and in more efficient utilization of by-products from fruit processing.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving chemists, biochemists, and chemical engineers engaged in both basic and applied research related to extending the use of fruits in the food processing industries. In the EU program apple products research, and investigations on the chemistry and cell structure of cherries are conducted at Wyndmoor, Pa. Development of rapidly-reconstitutable dehydrated fruit pieces is also underway at Wyndmoor. Contract research on peaches is in progress at Rutgers University, New Brunswick, and on apple texture at the Maryland Agricultural Experiment Station, College Park.

The Federal (EU) scientific effort devoted to research in this area totals 9.5 professional man-years. Of this total, research on chemical composition and physical properties constitutes 3.4 p.m.y., including 0.4 p.m.y. of contract research on apple texture at the Maryland Station. Research on new and improved food products amounts to 3.4 p.m.y., and research on new and improved processing technology amounts to 2.7 p.m.y., including 0.4 p.m.y. of contract research on peach processing at Rutgers.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations are engaged in a comprehensive program involving both basic and applied research on fruit processing and products. Evaluation of fruit varieties and selections is a necessary service for the breeding programs. Additionally the relationships of variety, other production and cultural practices, method of preparation, and processing procedures to quality and utilization of the finished product are determined. Application of mechanical harvesting is spreading rapidly, and makes it necessary to evaluate

how mechanical harvesting affects the utilization of the harvested fruit. Research is also in progress on the identification and characterization of changes associated with post-harvest storage and ripening. The aim is to elucidate the metabolic reactions associated with ripening with a view to their ultimate control. Degradative and structural changes are receiving most careful attention. In some cases the respiratory activity of the fruits is being measured to guide development of holding and packaging requirements.

Work on the chemical composition and physical properties of fruits involves studies of a number of fruits. For example, the non-volatile organic acids and sugars of grapes are being determined. Other studies involve the biochemistry of the color and pigments of fruits. Basic research is in progress on identification of the polyphenols of fruits and the role they play in enzymatic browning. Attempts are being made to isolate and identify the naturally occurring phenolic substances of commercially important fruits which affect the acceptability and stability of fruit juice products, wines, and dried and frozen fruits. Advances in methodology and biochemistry of plant tannins, leucoanthocyanins and related flavonols are being made. The chemical and physical changes of pectic substances before and after processing and during storage are related to texture and reconstitution properties of fruit products. It has been found that ethylene is important in the formation of peroxides and further investigation is concerned with the role of the lipid fraction in ripening of fruits.

Characterization of fruit flavors is being pursued by improved techniques of gas chromatography. Compounds are being identified and effort is being devoted to determining their significance in flavor of the fruit. Flavor variations and off-flavors are being studied also.

Investigation of enzymes specifically involved in the formation of off-flavors in frozen fruits is in progress. Studies of enzyme mechanisms and properties constitute an important fundamental phase of the fruit investigations. Browning problems and control of enzyme reactions are other facets of enzyme systems under study. Some effort is being devoted to synthesis of flavor compounds and pigments through use of extracted natural enzymes. Other analytical work involves determining flavor, texture and nutritional qualities.

The objectives of the microbiology program in fruit utilization vary from determination of the occurrence of certain organisms to study of yeast growth factors important in the wine fermentation. Microbiological spoilage receives careful attention. The use of vitamin K5 and its effect on the various food spoilage organisms is under study. Basic investigations of the ecology, taxonomy and physiology of yeasts and molds involved in food spoilage are made to better understand how spoilage microbes occur in nature and how they may be controlled in food products. A highly specialized study relates to the microbiology of olive fermentation and spoilage. Other research is concerned with the evaluation and enumeration of bacteria found in

frozen fruit products and developing methodology for identifying certain groups.

Research directed to development of new processing technology is a major component of the fruit utilization program. Study of the influence of maturity, post-harvest handling, storage and ripening procedures and processing methods on the quality of canned pear products is an example of a fully integrated project. Comprehensive studies dealing with the thermal processing of a number of fruits are in progress. Basic studies relate to mechanism of heat transfer, the effects of thermal processing and the mechanism of thermal breakdown of various constituents, i.e. fats, proteins, carbohydrates and heat labile vitamins. Methods, equipment and layout of processing lines also receive attention. Methods of freezing, dehydro-freezing, freeze-drying, irradiation and dehydration of fruits are investigated. The effects of the process on organoleptic, physical and chemical characteristics of the fruit are measured. For example, the optimal conditions for dehydrofreezing red cherries are being determined and the dehydro-frozen cherries are being evaluated for use in pies. Investigation of the effect of ultrasonic energy on freeze-drying rate is studied through consideration of the kinetics and mechanisms of energy and mass transfer. Effects of chemicals, hydrocooling, refrigerated storage and controlled atmosphere storage and holding are also under investigation. Because many of the changes in foods relating to processing methods are textural, a fundamental study of the influence of processing on microscopic structure of foods is in progress.

The objective of the product work is to develop new or improved food products. Development of processes or products to improve the utilization of fruits involves work on dehydrated fruits, i.e. prunes; apple juice, apple sauce; frozen fruit pies; apple-fruit juice blends; sherry wines, brined cherries; canned apple slices; low sugar apple jelly; macadamia nuts; peaches and grape products. Factors affecting fluidity, plasticity, consistency, shape, flavor, appearance, texture, physical, chemical and organoleptic properties are being studied.

Other work is concerned with storage of processed fruit items, packaging and containers, methodology for evaluation of fruit products, and the engineering problem of standardization, cooling, sizing and control of atmospheric conditions within packages.

The total research effort on fruit utilization is approximately 57.3 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemistry and cell structure of cherries for processing. Study continues on the nature of the changes, instigated by post harvest bruising, that are manifested by scald and other deficiencies in the processing of red tart

cherries. Enzyme preparations which act on cellulose, hemicellulose, starch, pectin and protein were applied to cherries. Microscopic examination of cells indicated no action of enzymes on the cell walls. In radioactive tracer investigations the output of $C^{14}O_2$ from bruised cherries was much greater following injection of C^{14} labeled acetic acid than from C^{14} labeled citric acid.

2. Factors influencing apple texture. In contract research (Maryland Agricultural Experiment Station) the relationship of apple cell wall constituents to texture of apple products is under investigation. No significant differences in cell wall structure of apples before and after storage at 32°F. for periods up to four months could be detected by staining techniques. The rate of softening in storage was found to vary directly with the level of pectin methylesterase activity in the tissue. This activity varies with the variety of apple, being highest in Golden Delicious and lowest in Stayman.

B. New and Improved Food Products

1. "Explosion-puffed" dried fruit pieces. Reports from industry continue to be favorable on tests of dry explosion-puffed apple pieces in cereal and snack items and of reconstituted segments for pies and compotes. In a study comparing varieties, firm-fleshed apples such as York Imperial were rated best for the process.

Explosive-puffed blueberries have been successfully tested in bakery products.

2. Improved apple cider. The formation of hydroxymethyl furfural (HMF), which accompanies the darkening of pasteurized cider on storage, was found to be accelerated by heat and acid and to increase with concentration of the juice. It appears that sucrose does not form HMF directly, but that HMF is formed after the sucrose is hydrolyzed to fructose and dextrose. Diethyl pyrocarbonate in proportions of 25 parts per million and above reduces the microbial count of fresh apple cider to a relatively low level. Combinations of this compound with potassium sorbate were superior to either preservative alone.

C. New and Improved Processing Technology

1. Processing characteristics of eastern peaches. Several promising new varieties of peaches were selected for further evaluation as a result of contract research (New Jersey Agricultural Experiment Station) on processing characteristics of 100 varieties. A common characteristic of the selected new varieties was an outstanding flavor. In general, the processed freestone peaches had better color than clingstone varieties.

2. Equipment development for explosion-puffing. Firing the "gun" at a slight downward angle emptied the chamber effectively, but aggravated the

problem of collecting the fragile pieces of fruit. A 25-foot long receiver-conveyer was installed, and further modifications have been made at the receiving end to minimize the problems of deceleration and collection.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

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PEACH PROCESSING AND PRODUCTS

Southern Utilization Research and Development Division, ARS

Problem. The peach industry in the Southeastern United States is dependent to a large extent on the fresh market. For example, in the South Atlantic States in 1962, 15,195,000 bushels of peaches were produced of which 12,237,000 bushels were sold on the fresh market; slightly less than 2,000,000 bushels were processed. A peach processing industry is needed in the Southeastern States to provide a profitable market for more of the edible peaches which do not meet fresh market standards and to rapidly convert a higher proportion of the overall crop to stable forms. Basic information, not now available, on the flavor components of peaches is needed to guide development of improved processed products from southern grown fruit.

Climatic conditions which favor rapid deterioration of fresh peaches both on and off the tree, erratic ripening periods and markets, and short lived peach orchards, are other factors contributing to the need for more extensively integrated fresh market-processing operations. There are technical problems preventing the more rapid development of the peach processing industry in the Southeastern States which must be overcome. Many of the peach varieties grown in the southeast require a modification of processing procedures to make satisfactory standard-type products. Still other varieties will not make standard-type products and new food forms must be found for them. Recent rapid advances in food science and processing technology make it possible through research to develop both new and improved peach products. These are needed to bolster the economics of the South's peach industry, as well as to provide the superior qualities, and greater convenience in food products, which the consumer now demands.

USDA AND COOPERATIVE PROGRAM

The Department has a program of basic and applied research on peaches being conducted under contract at the Georgia Agricultural Experiment Station, University of Georgia, Experiment, Georgia. Food chemists and food technologists conduct this research. Research to develop basic information on chemical composition and physical properties of peaches, particularly varieties grown in the Southeastern States, is in progress under one contract. Specifically, the objective of this research is to isolate, identify, and characterize the constituents of peach flavor and aroma, and acquire information needed to guide development of improved processed products from the fruit. Another contract, in the field of new and improved food products and processing technology, is concerned with research to develop optimum procedures for the production and preservation of puree and clear juice peach concentrates; to develop optimum procedures for the preparation and the handling under simulated commercial conditions of refrigerated fresh peach slices; to develop optimum procedures for canning Southeastern peaches; and to conduct experiments directed to the development of partially

dehydrated pasteurized peach products. Evaluation of different varieties of peaches, and of different processing variables are phases of the investigations. This research is carried out with the support of the Area Redevelopment Authority of the Department of Commerce.

The contract research involves a total level of effort of 2.0 man-years, 0.8 being on chemical composition and physical properties and 1.2 on new and improved food products and processing technology.

PROGRAM OF STATE EXPERIMENT STATIONS

No report for this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. New and Improved Food Products and Processing Technology

1. Development of New and Improved Processed Products from Southeastern Peaches. New and improved processed products made from the 1963 crop of southeastern peaches by the contractor (Georgia Agricultural Experiment Station) have now been evaluated. For canned peaches, numerous variables have been investigated: for example, variety, postharvest treatment, conditions of processing, and degree of ripeness. Evaluation of the effect of these variables established criteria for canning to produce good quality products. It is anticipated that chilled peach sections and a 2-fold puree-type concentrate will be prepared on a commercial scale and market tested in 1964. Fully ripe peaches of both freestone and clingstone varieties can be used for the concentrate. A clear juice concentrate is suitable for disposition of cull peaches and varieties that cannot be utilized for other products. In the 1963 season, approximately 15,000 gallons of 60° Brix concentrate were produced commercially, primarily for use in wine. It is being tested further for other applications, for example, as a topping for ice cream and desserts and as a flavoring for waffle syrup. Research to develop a partially dehydrated pasteurized peach product has not yet been as successful as for the other products. The present research has demonstrated that high quality products can be prepared from southeastern peaches; the major research effort in the 1964 season will be on canned peaches and chilled sections, with continuing work on the pureed, dehydrated, and concentrated products. (SU-0-0-1 (DC)).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None

PROCESSING AND PRODUCTS

Western Utilization Research and Development Division, ARS

Problem. Fruits and nuts are valued for their unique flavor, color, and natural vitamin content. In the period of abundance at harvest time, markets are glutted and growers often do not get an adequate return. Crops are perishable, and processing to preserve their unique qualities is difficult. No processed fruit retains completely the fresh values, although many highly acceptable products exist and about half of the fruits and nuts marketed in the United States are processed. Processing makes these commodities available to consumers the year around, and has opened new markets for producers. The proportion of processed commodities is steadily increasing but is dependent upon a continuing flow of new knowledge. Processing to preserve color, flavor, and texture presents many problems generally, and each new product requires the application of much scientific and technological skill.

The freezing process for preserving certain fruits keeps the products excellent at near fresh fruit condition. In spite of the gains in quality realized in freezing, many unsolved problems remain. The enzymatic browning of frozen peaches and the sloppy texture of frozen strawberries on thawing are two good examples.

Frozen fruits require expensive low-temperature storage and transportation facilities. The expense is greatly reduced by removing a portion of the water from the products. Orange and other fruit juice concentrates are well established in U.S. markets, and dehydrofrozen apple slices (rapid drying to 50% bulk weight and then freezing) are just becoming well established. Many other fruits and fruit juices should be amenable to concentration. Products of this type, however, are not so well adapted for export as those which do not require refrigeration.

The maximum weight reduction can be achieved through dehydration. The drying of fruit juices has been successfully accomplished by the vacuum puff drying and foam-mat drying processes. The latter is under intensive study, because it can be carried out at atmospheric pressure and consequently offers economy in processing. This process must be worked out in detail for many, as yet untried, fruit purees and juices and on pilot-plant scale for those products that show promise. Flavor recovery and the incorporation of recovered flavor in solid carriers for addition to the dried products require technological and basic chemical study. Essence recovery techniques developed for fruit juice concentrates are not completely satisfactory for this purpose.

Dried and canned fruits are now widely used in the U.S. and abroad. The popularity of dried fruits overseas and in this country would grow if stable, higher moisture dried fruits were available and if lower levels of sulfur

dioxide could be used without loss of quality.

Container costs for canned fruits limit the shipment of these products overseas. A solution of the container problem may be found in the use of lightweight fiber, foil, or plastic containers and aseptic filling procedures.

Fruit growers need new varieties of tree fruits and berries suited to processing and resistant to diseases endemic to each region of production. Utilization research is required in cooperation with farm research to assure growers of a market for fruit in the processing industry.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic and applied research on deciduous fruits and tree nuts is conducted at the Division headquarters at Albany, California; in field stations at Pasadena, California, Prosser and Puyallup, Washington; by contract in Honolulu, Hawaii; by grant at Cambridge, Massachusetts; and by grant funds under P.L. 480 in Israel and India. Fundamental research is conducted on fruit constituents that are involved in the flavor, color, and texture of fruit products, and includes development of laboratory tools to isolate and characterize individual components, investigation of such components as they occur naturally and as they are altered by operations involved in preservation, and the relationships between the components and the product values being preserved. Applied research is conducted to develop new and improved processes and products that will increase utilization of fruits and tree nuts, including the development of high quality concentrated and dehydrated products and more stable shelled tree nuts and the selection of improved processing varieties. Pioneering research on plant enzymes is also conducted.

The Federal program of research in this area totals 48.2 professional man-years, including two scientists whose salaries are provided by two cooperators (Dried Fruit Research Advisory Committee, whose membership represents the California Raisin Advisory Board, the Dried Fig Advisory Board, the California Prune Advisory Board, and the Dried Fruit Association of California; and Diamond Walnut Growers, Inc. - one each), under Memoranda of Understanding; one grant providing research at a rate of approximately 0.5 professional man-year per year and four contracts providing research at a rate of approximately 2.6 professional man-years per year. Of this number, 26.7 are assigned to investigations on chemical composition and physical properties; and 21.5 on new and improved food products and processing technology. In addition, the Division sponsors basic research on fruit by means of two P.L. 480 grants.

PROGRAM OF STATE EXPERIMENT STATIONS

State stations are engaged in a comprehensive program involving both basic and applied research on fruit processing and products. Evaluation of fruit varieties and selections is a necessary service for the breeding programs. Additionally the relationships of variety, other production and cultural practices, method of preparation, and processing procedures to quality and utilization of the finished product are determined. Application of mechanical harvesting is spreading rapidly, and makes it necessary to evaluate how mechanical harvesting affects the utilization of the harvested fruit. Research is also in progress on the identification and characterization of changes associated with post-harvest storage and ripening. The aim is to elucidate the metabolic reactions associated with ripening with a view to their ultimate control. Degradative and structural changes are receiving most careful attention. In some cases the respiratory activity of the fruits is being measured to guide development of holding and packaging requirements.

Work on the chemical composition and physical properties of fruits involves studies of a number of fruits. For example, the non-volatile organic acids and sugars of grapes are being determined. Other studies involve the biochemistry of the color and pigments of fruits. Basic research is in progress on identification of the polyphenols of fruits and the role they play in enzymatic browning. Attempts are being made to isolate and identify the naturally occurring phenolic substances of commercially important fruits which affect the acceptability and stability of fruit juice products, wines, and dried and frozen fruits. Advances in methodology and biochemistry of plant tannins, leucoanthocyanins and related flavonols are being made. The chemical and physical changes of pectic substances before and after processing and during storage are related to texture and reconstitution properties of fruit products. It has been found that ethylene is important in the formation of peroxides and further investigation is concerned with the role of the lipid fraction in ripening of fruits.

Characterization of fruit flavors is being pursued by improved techniques of gas chromatography. Compounds are being identified and effort is being devoted to determining their significance in flavor of the fruit. Flavor variations and off-flavors are being studied also.

Investigation of enzymes specifically involved in the formation of off-flavors in frozen fruits is in progress. Studies of enzyme mechanisms and properties constitute an important fundamental phase of the fruit investigations. Browning problems and control of enzyme reactions are other facets of enzyme systems under study. Some effort is being devoted to synthesis of flavor compounds and pigments through use of extracted natural enzymes. Other analytical work involves determining flavor, texture and nutritional qualities.

The objectives of the microbiology program in fruit utilization vary from determination of the occurrence of certain organisms to study of yeast

growth factors important in the wine fermentation. Microbiological spoilage receives careful attention. The use of vitamin K₅ and its effect on the various food spoilage organisms is under study. Basic investigations of the ecology, taxonomy and physiology of yeasts and molds involved in food spoilage are made to better understand how spoilage microbes occur in nature and how they may be controlled in food products. A highly specialized study relates to the microbiology of olive fermentation and spoilage. Other research is concerned with the evaluation and enumeration of bacteria found in frozen fruit products and developing methodology for identifying certain groups.

Research directed to development of new processing technology is a major component of the fruit utilization program. Study of the influence of maturity, post-harvest handling, storage and ripening procedures and processing methods on the quality of canned pear products is an example of a fully integrated project. Comprehensive studies dealing with the thermal processing of a number of fruits are in progress. Basic studies relate to mechanism of heat transfer, the effects of thermal processing and the mechanism of thermal breakdown of various constituents, i.e., fats, proteins, carbohydrates and heat labile vitamins. Methods, equipment and layout of processing lines also receive attention. Methods of freezing, dehydrofreezing, freeze-drying, irradiation and dehydration of fruits are investigated. The effects of the process on organoleptic, physical and chemical characteristics of the fruit are measured. For example, the optimal conditions for dehydrofreezing red cherries are being determined and the dehydrofrozen cherries are being evaluated for use in pies. Investigation of the effect of ultrasonic energy on freeze-drying rate is studied through consideration of the kinetics and mechanisms of energy and mass transfer. Effects of chemicals, hydrocooling, refrigerated storage and controlled atmosphere storage and holding are also under investigation. Because many of the changes in foods relating to processing methods are textural, a fundamental study of the influence of processing on microscopic structure of foods is in progress.

The objective of the product work is to develop new or improved food products. Development of processes or products to improve the utilization of fruits involves work on dehydrated fruits, i.e. prunes; apple juice; apple sauce; frozen fruit pies; apple-fruit juice blends; sherry wines; brined cherries; canned apple slices; low sugar apple jelly; macadamia nuts; peaches and grape products. Factors affecting fluidity, plasticity, consistency, shape, flavor, appearance, texture, physical, chemical and organoleptic properties are being studied. Total professional man-years equals 57.3.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Fruit Pigments. Red, purple, and blue anthocyanin pigments are responsible for color of many fruits. The changes that occur in these pigments during processing and storage adversely change the appearance of their

products. Basic studies of the nature of anthocyanin pigments are continuing. Studies of model chemical systems of flavylium salts are revealing the course of chemical modification of this type compound and pointing the way to procedures for stabilizing fruit color. A significant finding of these studies previously reported was the oxidative rearrangement of flavylium salts to 2-aryl-substituted benzofuran derivatives. One of these new compounds, coumestrol, has estrogenic activity and has been isolated from alfalfa and other legume forages. The conversion of flavylium salts to coumestrol compounds was also demonstrated in laboratory animals.

Model anthocyanidin pigments were decolorized in laboratory studies by reaction involving other phenolic compounds. For example, such phenolic compounds as fluoroglucinol, resorcinol, and catechin which occur in most plant extracts rapidly reduce flavylium salt to a colorless flavin. Although it is commonly assumed that oxidation of anthocyanins is responsible for most color loss in fruit products, this newly observed phenol reaction strongly suggests that decoloration of anthocyanins might be due at least in some instances to a reduction of the pigment by ubiquitous phenolic compounds. Whereas these studies involve only model chemical systems, research will ultimately seek to find if this reaction occurs in fruit juices. If it does, a number of new approaches to color stabilization should be considered.

Basic research on leucoanthocyanins and related phenolic pigments in fruits was initiated by contract at the University of California at Los Angeles. The studies will include the biological formation and changes of leucoanthocyanins and related flavonoid compounds in fruits to determine the nature of the oxidative and other reactions responsible for changes of these chemical compounds during processing and storage. A related project on the chemical behavior of leucoanthocyanins in fruits was initiated at the University of Delhi in India under Public Law 480 funds. Mechanisms, such as reactions with sulfur dioxide, involved in color changes will be studied to develop means for controlling darkening and other color deterioration in processed fruit. Pigments were extracted from the peels of apples, pomegranates, and peaches and found to contain appreciable amounts of leucoanthocyanins. Isolated leucoanthocyanins from these sources are being further characterized and studied.

2. Enzymatic Browning of Fruit. Basic research on a methyl transferring enzyme led to a procedure for preventing discoloration of cut apple surfaces. Observations on the apple tissue suggested an enzymic action similar to methyl transferase systems previously isolated from animal liver tissue. Further study revealed plant sources of such an enzyme. O-methyl transferase was easily extracted from pampas grass which is a possible source of the enzyme as a chemical reagent. A number of important phenolic metabolites of plants and animals were tested and methylated through the action of the enzyme. A quantitative radiochemical assay of high sensitivity was worked out to test protein fractions for methyl-transferring activity. The new analytical procedure was used in isolating purified enzyme fractions from protein extracts. Studies of the specificity of purified enzyme fractions

can now be conducted. In addition to the potential of preserving color of cut fruits, this basic research has important implications on the organic synthesis of methoxy phenolic compounds. Several fruits were tested for the presence of O-methyl transferase activity and found negative. The absence of this enzyme implies the necessity of developing a suitable reagent enzyme from other sources.

Related studies on enzymic browning of fruits are conducted at the Hebrew University in Jerusalem, Israel, under P.L. 480 grant funds. Electrophoretic separation of enzymes from apples was advanced. Several components with phenolase activity were isolated and studies were conducted on the inhibition of phenolase by chemical reagents. An inhibitor, highly specific for phenolase, showed that peaches contain a soluble enzyme that oxidizes phenols but is not inhibited as are other phenolases. With the next harvest of peaches this interesting enzyme will be studied in greater detail. In addition, peaches were found to contain other phenolases that resemble in all essentials the enzymes that were found previously in apples. A soluble apple enzyme that was not found in unripe apples apparently is formed or liberated from particulate fractions during ripening. Studies on this enzyme will continue in order to follow its development in ripening apples including studies in which ripening will be accelerated with ethylene. The properties of this enzyme will be investigated if it is found present in sufficient amount for isolation.

3. Chemical Origin of Plant Structural Tissue. The biological pathways whereby polysaccharides of cell wall and other structural tissues are formed and degraded in fruit are under investigation because such compounds affect the texture of fruit and fruit products. A searching investigation of biochemical interrelationships between cell wall polysaccharides and myo-inositol (a simple carbohydrate compound found widely in nature) has revealed an important chemical process that involves the positioning of elements within these molecules. Radiotracer techniques were used to follow the production of D-xylose by ripening strawberries. These studies explained the conversion sequence from myo-inositol to D-glucuronate to D-xylose.

The study on the conversion of myo-inositol to cell wall polysaccharides and related carbohydrates in fruit tissue revealed this compound as a potent tool for basic study of cell wall components, especially pectin and hemicellulose. When myo-inositol is specifically tagged with radioactive elements the label appears specifically in uronic acid and pentose residues of the cell wall polysaccharides. It is thus possible to insert radioactive labels in certain components of the cell wall to the exclusion of other carbohydrate components such as cellulose. The selective radioactive tagging should be useful for studies of processing and storage variables on the texture influencing components of fruit tissue.

A related research grant was initiated at Harvard University to seek information on the formation and physical structure of fruit cell walls. They are now undertaking detailed histochemical investigations of plant cell wall

structures. A new tissue fixative, glutaraldehyde, was used in sample preparation and initial studies gave evidence for the first time of an ordered array of intracellular microtubules just inside the cell membrane in a wide variety of plant tissues. The observation provides the first glimpse of an ordered pattern of cytoplasmic processes conceivably responsible for ordered cellulose fiber deposition in the cell wall. Further, it offers a rational phylogenetic explanation for processes related to protoplasmic streaming, since the microtubules of these plant tissues seem to resemble the ciliary processes of bacteria and animal cells. The functions of the microtubules in plant tissues will be explored in depth as this project continues.

4. Pharmacological Investigations--Deciduous Fruit. Treatment of high-moisture dried fruits with ethylene oxide has been reported to result in residues of ethylene and diethylene glycol. Approval by Food and Drug Administration for use of ethylene oxide requires the development of an analytical method for the glycol residues, so they may be measured and controlled at non-toxic levels. It was demonstrated that when known amounts of ethylene glycol, the principal breakdown product of ethylene oxide and water, were added to high-moisture dried fruit that had not been treated with ethylene oxide, only 75-85% of the glycol could be recovered. A paper-chromatographic isolation technique has now been developed which makes it possible to quantitate the ethylene-oxide residue in high-moisture dried dates.

The enzyme O-methyl transferase has been found effective in preventing enzymic discoloration of cut and peeled fruit. Enzyme-substrate studies are under way in biological systems. A variety of orthodiphenolic compounds, including phenolic acids, phenols, coumarin, and flavonoids were found to be suitable substrates for this enzyme.

5. Fruit Flavor Components. Refinements in gas-liquid chromatography (GLC) continue to advance chemistry of volatile components of fruits. Large-bore capillary columns and packed columns of low pressure-drop and high efficiency were developed to prepare pure samples of compounds heretofore very difficult to isolate. GLC retention data provide rapid, tentative identification of many compounds. Combination of GLC with time-of-flight mass spectrometer analysis separates and identifies substances in fractions of a part per million including compounds whose separate existences are transitory. Spectral data other than mass spectra are useful to establish chemical structure of difficult compounds. Milligram quantities of pure material must be isolated to obtain these spectra and these new highly efficient columns will help to prepare such samples as well as the samples of individual volatile components of fruits needed for taste evaluation.

Studies were initiated to develop tissue cultures from flavor-rich grape varieties. These cultures grown in the bland juice of Thompson seedless grapes appear on the basis of preliminary investigations to give some of their own flavors to the Thompson juice. Controlled fermentation of tartaric acid with the "noble rot" mold also improves flavor of Thompson juice.

6. Pioneering Research: Ethylene Metabolism in Fruit. The enzymes involved in the metabolic fate of ethylene in fruit under conditions wherein ethylene hastens the post-harvest maturation continue to be investigated, using ethylene labeled with C^{14} and with H^3 . From a comparison of the amount of radioactivity and the labeling pattern of the toluene and benzene arising from the metabolism of the two labeled ethylenes, it could be postulated that during the metabolism of ethylene a considerable portion of the hydrogen is removed from ethylene by some dehydrogenation process, and this hydrogen proceeds along a pathway different from that followed by the carbon as illustrated by the labeling of toluene. Part of the hydrogen and carbon are metabolized along the same pathway as illustrated by the labeling of benzene. This postulate suggests that acetylene, which produces some of the same effects on plants as does ethylene, may yield some of the same metabolites as does ethylene- C^{14} . This was found to be true. Acetylene- C^{14} was metabolized to an extent ten times as great as was ethylene- C^{14} . A large proportion of the metabolized acetylene was found in benzene. The isolation and identification of other volatile and non-volatile metabolites of labeled ethylene are continuing in order to obtain additional information about the enzymes involved in the maturation of fruit with the ultimate goal of controlling maturation prior to processing.

Protein Synthesizing Enzymes. The first step in protein synthesis is the activation of the individual amino acids and their transfer to ribonucleic acid (RNA). Each amino acid presumably has a specific activating enzyme and a specific RNA to which it is attached. The structure and conformation of the RNA molecule required for acceptance of an amino acid is under study. The secondary structure of RNA is disrupted by the presence of relatively large amounts of purines. It has now been established that purines are without effect on the activation reaction. However, the effect of disruption on the transfer reaction remains to be established.

Biosynthesis of Diosgenin. The role of steroids in plant tissue, particularly as related to enzyme action and the control thereof, is under investigation. One of the several steroidal sapogenins which occur in certain plant tissue is diosgenin. The following sequence of reactions has now been demonstrated by administration of radioactive precursors to plants and isolation of the radioactive products by thin-layer chromatography: Acetate \longrightarrow mevalonate \longrightarrow squalene \longrightarrow cholesterol \longrightarrow cryptogenin \longrightarrow diosgenin.

Desoxyribonucleic Acid Polymerase. The control of enzyme action and physical properties of plant tissue is through the genetic information contained in the desoxyribonucleic acid (DNA). In nature the DNA is associated with histones (basic proteins) whose presence presumably regulate the synthesis of enzymes. In order to obtain more information in this deep-seated question of genetic control of enzyme action, the influence of the presence of histones on DNA replication in vitro was investigated. It has been found that pea DNA complexed to histone can function as a template for DNA replication, but only to a limited extent as compared with uncomplexed DNA. Further pioneering research on the possible control of enzyme action through such a basic approach will be pursued.

Chemical Origin of Plant Structural Tissue. The chemistry and biochemistry of formation of plant cell walls is under investigation because of the obvious importance of cell walls to such characteristics as texture, turgor, and cell elongation. The reproducible tissue culture of tobacco cells as a model system is used in this investigation. The proteins of these cells can be separated into protoplasmic, cell wall-extracted and cell wall-residual fractions, each with its different amino acid composition, particularly with respect to the amino acids, proline and hydroxyproline. The protein of the cytoplasm has a high biochemical turn-over whereas that of the cell wall is very low, suggesting that the former is converted to the latter. Characterization by electron microscopy autoradiography of the cell wall proteins and their role in cell wall structure and properties will continue with particular emphasis on their synthesis and deposition in the cell wall.

B. New and Improved Food Products and Processing Technology

1. Dried Fruit Products. Research on new and improved dried fruit products continues, supported in part by the Dried Fruit Industry Research Advisory Committee, which provides the salary of one of the scientists assigned to this work. A process for making a non-setting raisin paste was reported earlier. Raisin paste can be used in many bakery formulations, but heretofore tended to set in a hard lump so the bakers had to prepare it just before use. The process was improved by use of a drum dryer. An extremely short-time heat treatment retarded setting of raisin paste. Ground raisins in contact with the surface of a drum dryer for as short a time as 28 seconds with the drum heated to 190-200° F. remained soft and pliable. Only about 1% of the moisture was lost during the treatment.

Stability studies of dried fruit continued. Storage life of conventionally dried apples was determined to be about 4 months at 90° F., 11 months at 70°, and well over a year at 50°. The darkening rate of apples was approximately 30 times greater at 90° than at 50°. When sulfured dried fruits with different levels of sulfur dioxide are packed together, the protective chemical migrates from the fruit with the higher sulfur dioxide level to the others. For example, prunes which are not normally sulfured were found to contain as much as 900 p.p.m. SO₂ due to migration from cut fruits in the same package.

High quality dehydrated Comice pears (a winter variety) were produced by the DBD method (partial drying--steam blanching--finish drying). Commercial interest in the process exists for marketing in a high-quality specialty market area.

2. Fruit Dehydration. A novel dehydration procedure for pieces of fruit was developed. Fruit pieces were dried in a matrix of various sugars, starches, or celluloses. These matrices provide a medium for heat and moisture transfer and have been used over a range of conditions including vacuum drying, fluidized bed drying, and as pre-treatments before stationary

hot air drying. Color and texture of dehydrated or partially dehydrated fruit was best with a sucrose matrix. Fruit slices were prepared for dehydro-freezing with crystalline sucrose. The partially dehydrated product had color, texture, and flavor equivalent to fresh fruit. These exploratory studies, in which moisture is withdrawn from the fruit by the difference in osmotic pressures between the material within the tissue cells and the dry matrix, open the door to a wide range of new possibilities in the dehydration of foods. Apple wedges or slices, or other fruits such as whole berries, were stored with an equal weight of sugar overnight at room temperature or for about 2 hours at 120° F., preferably after a dip in a weak sulfur dioxide solution. Treatment reduced the fruit to about 50% of its original weight and the sugar has become a heavy syrup. The fruit was separated from the syrup and dried in hot air at 160-180° F. to a moisture content as low as 3-4%, if desired. The dried product had excellent color and flavor. The first step in which water was removed by osmosis appeared to set the structure so that the remaining water was easily removed to a very low moisture content. It is a slow process to prepare dried apple slices below 20% by conventional methods because the structure collapses in the early stages of dehydration and resists transfer of moisture. Larger quantities of osmotic dried apple slices are being prepared on pilot scale for chemical and taste evaluation. The improved quality apparent in these dried apple slices makes them appear of potential value in domestic markets even though dried apple slices as they now exist have very limited demand. Fruit dried in this way needs little sulfur dioxide as a preservative and retains good flavor. The heavy syrup produced by the withdrawal of moisture from the fruit has a very good flavor of the fruit processed. The growing use of fruit-flavored syrups for breakfast use may offer a valuable market for this byproduct of the osmotic dehydration process. As an alternative process, the initial drying can take place in heavy syrup instead of a sugar matrix and the syrup can be concentrated and recycled.

3. Texture of Processed Fruit. Serious outbreaks of brined cherry softening have plagued the Northwest cherry industry from time to time in the past several years. Cooperative studies have been conducted with the Oregon and Washington State Agricultural Experiment Stations and with interested processors and growers to determine the cause and develop controls. After several years of study, all the causes of deterioration of brined cherries are still unknown, although activity of pectic enzymes has been frequently detected and is almost certainly involved. The sources of the pectinolytic enzymes may be several. However, procedures aimed at inactivating enzymes and firming the pectic materials in brined cherries were developed that gave good protection against deterioration. Heating cherries to 160° F. either before brining or in the brine prevented enzymic softening. High-calcium brines also protected against softening. Commercial processors are interested in the possible re-use of brine in cherry preservation for economy and to avoid problems of waste disposal. Brine that was used three seasons in a commercial plant produced satisfactory firm cherries except in tanks of brine containing active pectinolytic enzymes. However, the firm cherries, after being processed into maraschino cherries, developed undesirable brownish red color

in prolonged storage of the finished product. The color degradation has not yet been unequivocally linked to the re-use of the brine, because a new dye formula was involved in the maraschino process.

4. Grape Juice and Grape Products. Research on viniferous grapes is continuing to seek new products that will enlarge markets for wine grapes grown beyond the needs of current markets. Principal attention is directed towards Thompson seedless grapes which are the major surplus burden. Diethylpyrocarbonate was tested as a chemical sterilant to avoid cooked flavor developed by pasteurization to allow pure culture fermentation improvement of Thompson seedless grape juice. It was possible to grow pure submerged cultures of Botrytis cinerea (noble rot) which metabolizes tartrate in the juice and develops improved flavor. The conversion of the non-metabolizable tartaric acid, would make the grape juice more desirable in food products such as baby foods. Cultivation of Botrytis cinerea (which grows on grapes fortuitously in some seasons in some parts of Europe to make very high-quality wines), in non-alcoholic grape juice improved flavor substantially as judged informally by scientists working on the project. We devised a scrubbing apparatus for filterless sterilization of the input air, which acts as an agitator and source of oxygen in submerged culture fermentations, and also conducted chemical studies of the acid changes in aldehyde formations.

Osmotic concentration of grape juice by dialysis demonstrated the possibility of reaching 64° Brix in three hours. Several membranes were tested in this new process. Experiments with common commercial cellophane indicated the feasibility of concentrating the juice by use of salt as the hypertonic solute. No acidification was found necessary if cellophane was the membrane. This simplified the subsequent concentration of hypertonic medium which is necessary as it approaches equilibrium with the grape juice.

After seven months' storage at 0° F. commercial Concord grape flavor concentrate lost more methyl anthranilate than samples stored for the same period at 32° and 60° F. In this storage time losses in total volatile esters remained negligible at both 0° and 32° F. and amounted to only 10% at 60° F. For purposes of economic efficiency commercial production of grape juice concentrate requires that the product be stored in bulk as it is produced during and soon after the harvest season. It is not known what the optimum storage conditions are for the concentrate nor is it known whether it is feasible or desirable to remove volatile esters and store them separately from the concentrate until they are finally packed. Preliminary laboratory tests are being conducted on grape and apple concentrates.

5. Processing Quality of Varieties of Northwest Fruit and Berries. Fruit and berry selections are evaluated in cooperative research with the Washington State Experiment Station. The choice of varieties of strawberries and raspberries for processing in the Pacific Northwest depends very much upon these cooperative studies. In 1963, 92% of the strawberry crop was from new varieties developed by the Experiment Station and tested for processability by Department scientists. Raspberries, blackberries, blueberries, apricots, and cherries were evaluated during the past year.

Fifteen selections of strawberry crosses are now left from 10,000 seedlings planted in 1960. The detailed studies that will now be possible on the reduced number of seedlings remaining should provide additional varieties that will be superior in both production and quality for release to commercial growers.

The current leading commercial raspberry varieties accounting for nearly 90% of all raspberries grown in Washington, were tested extensively over several years at the Puyallup station for processing suitability before release to the trade. Two apricot varieties and two cherry varieties of early maturity, which were recently released by the State Station, also were tested. So large a proportion of the berries and fruit grown in the Pacific Northwest is processed that new varieties must adapt to processing in order to succeed.

6. Improved Fruit Juices and Fruit Juice Processes. The initiation of a pack of full-flavored concentrated frozen apple juice was a major development in apple processing in the Pacific Northwest. The commercial operation is based on developments of the Western and Eastern Utilization Research and Development Divisions and the extension of laboratory and pilot plant data to a successful commercial venture was carried out with technical assistance from the two Divisions. Specific technical problems were anticipated from the small but important amounts of starch in apple juice. Enzyme treatment was found essential to produce stable frozen concentrated apple juice during the early season when appreciable starch is present. An iodine test for starch in apple juice as the juice enters the concentrator was found to be a useful index of final stability. One-year storage tests on frozen concentrated apple juice, which had received no treatment to remove pectin, showed no evidence of pectin gel formation during frozen storage.

Efficiency of operation and maximum recovery of juice from apples depends upon maintaining a minimum of insoluble solids in the pressed raw apple juice. It was found essential that the apple pulp not be manipulated more than absolutely necessary between milling and pressing in a rack and cloth press in order to maintain low insoluble solids content.

An improved apple juicing system was conceived and tested on recently harvested and stored apples two months and six months after harvest. The conventional rack and cloth press was replaced by a sanitary basket centrifuge and a vertical screw press system using standard pieces of food processing equipment. Tests were run in the Pacific Northwest in October, December, and April. Gross yields of apple juice were 10% greater than for rack- and cloth-pressing; pectinol lees were about 10% lower.

7. Stabilizing Shelled Nuts. The attractive appearance and convenience of shelled nuts is increasing the proportion of nuts sold in this form. Once the shells are removed, kernels tend to darken and turn rancid rather quickly. An investigation of the deterioration of shelled nuts is supported

in part by the Diamond Walnut Growers, Inc., which supplies the salary of one chemist assigned to the Pasadena, California Laboratory. Detailed analyses of fresh and rancid walnut kernels revealed that changes in the nitrogenous constituents and volatile organic compounds occur during the development of rancidity. One unknown compound in the basic amino acid fraction was destroyed and a number of new compounds were formed during rancidity development, suggesting interactions between the nitrogenous constituents and lipid oxidation products. The volatile products of lipid oxidation will now be studied to determine their chemical nature and interaction with nitrogenous and other compounds during the development of rancidity.

Research on the stability of fresh and roasted Macadamia nuts was concluded under a contract with the University of Hawaii. Three varieties of Macadamia nuts were shelled, roasted and evaluated for stabilities at three moisture levels over a reasonable temperature range, protected and unprotected from light. Low-temperature storage in the dark increased stability. For samples stored at 1%, 2.5% and 4% moisture, rancidity increased as moisture decreased.

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NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, and on the nutrient and other values of foods and on how to conserve or enhance these values in household preparation and processing. Periodic surveys of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective programs in nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and consumer use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas total 63.3 man-years. It is estimated that approximately 11.5 man-years is concerned with studies related to deciduous fruit and tree nuts.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 26.7 professional man-years and is described in detail in the report of the Human Nutrition Research Division.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Nutrient Value of Food

Food composition and nutritive value are most frequently related to indigenous agricultural products. Specific and locally grown raw products are being extensively evaluated for essential nutrients, especially in Hawaii and Puerto Rico. Much work is related to changes induced by growing practices, processing and storage.

Certain raw products are being evaluated for their significant vitamin contribution to nutrition. The effect of production and processing practices on vitamin content continues as an area of interest. Additionally, research has been directed toward the study of vitamins in foodstuffs as affected by inhibitory and stimulatory factors.

The total program in this area includes 36 projects in 23 States and is comprised of 23.4 professional man-years.

Properties Related to Quality and Consumer Use of Food

In the area of food preparation, products are related to quality by some measure. Special measures characterize certain classes of products; i.e., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues. Combinations of these are involved in the quality evaluation work reported.

Comparative studies are being carried out on fruits and vegetables processed by freezing, canning and irradiation.

Food preparation research focusing on products for home use include: Microwave preparation of meats, fruits and vegetables, including the chemical alterations involved; and flavor characterization in frozen and stored products by means of vapor component identification.

This portion of the program includes 52 projects in 21 States and is comprised of approximately 50.1 professional man-years. This is a partial report of the State Experiment Station programs in food science and includes work undertaken by home economics departments. For research on food and fiber utilization see reports of the Utilization Research and Development Divisions.

Food Consumption and Diet Appraisal

The State program in food consumption and dietary appraisal extends the work of the Department to other segments of the population or to geographic areas not separately identified in the nationwide studies. Currently 12 States are contributing to this program. One regional project is designed to yield information regarding food purchase and consumption patterns of families with preschool children. Food habits will be evaluated in terms of the children's dietary needs. This research will provide information useful to both consumer and market interests. In the Western Region ongoing research on consumer satisfaction with selected fruits and vegetables is nearing completion.

The State program in this area totals 22.2 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Nutrient Value of Food

1. Tables of food composition. Research for the newly revised Agriculture Handbook No. 8 "Composition of Foods...raw, processed, prepared" has been supplemented by further research during the year and adapted to the needs of special projects.

Formulas and procedures that were used in calculating the nutritive values of 250 food items commonly prepared at home are being summarized in a publication for special users, particularly therapeutic dietitians and medical research workers. A table showing average adjustments for vitamin losses during cooking has been developed and will be included in the publication.

Selected data from revised Handbook No. 8, have been made available in decks of punched cards and magnetic tape for research workers. Available in these forms are the data from Table 1, the nutritive values for 100 grams edible portion of the foods; from Table 2, nutritive values for one pound of food as purchased; from Table 3, selected fatty acids in foods.

Tables for the Department of Defense have been prepared on the composition of 630 food items procured by the Defense Supply Agency for feeding military personnel. Values for the composition of foods developed for Handbook No. 8 and many additional values provided by the Department of Defense were used to develop the data needed for the numerous special food products meeting military specifications.

2. Vitamins. Analyses for the vitamin B₆ content and distribution in fruits, nuts, cereal foods, and cheeses available to and as eaten by consumers are nearly completed. Manuscripts are in preparation. Analyses on meats and vegetables are in progress.

A fluorometric procedure for the determination of pyridoxine as pyridoxal cyanohydrin was developed. The reactions were quantitatively reproducible over a range in concentration of 1 millimicrogram to 1 microgram per milliliter. Procedures for chemical assay for pyridoxal and pyridoxamine previously had been developed in this laboratory. Present studies are to adapt chemical procedures to analyze food extracts for the three forms of vitamin B₆. The procedures are expected to provide a more constantly reliable method for measuring this vitamin. Values from the chemical procedures are being compared with values obtained by microbiological determinations for vitamin B₆ in foods.

Development of coordinated procedures for B-vitamin analyses continued with emphasis on a rapid, stable chemical method for nicotinic acid.

3. Mineral elements. Laboratory analyses for mineral element content of 29 fresh and 6 dried fruits were completed and statistical analyses are in progress. Results presently available indicate that sodium as well as aluminum, boron, copper, iron, and manganese occur in minor amounts in fruits. The lowest calcium and magnesium values were found in apples. The mineral element content of the fruits varied within and among production areas. All mineral elements were not equally affected. Lot-to-lot variation of avocado, blackberries, and fresh apricots was significant for seven of the 10 elements analyzed. A manuscript giving details will be prepared.

4. Carbohydrates. Research is continuing on improving methods for analyses of individual sugars and applying them to various foods. Studies are concerned with extraction procedures, the determination of total and reducing sugars by conventional methods, and glucose and fructose by differential oxidation. Thin layer chromatography has been used for the separation and identification of some individual sugars from fruit and vegetable extracts.

Total and reducing sugars, sucrose, dextrin, and starch content of dry fat-free solids of composites representing 14-day diets for 16 to 19 year-old boys were determined. The diets were based on USDA food plans at moderate cost. Variations among, and correlation coefficients between, different carbohydrate fractions were calculated. Sucrose content varied more than any other carbohydrate constituent. Variations among other carbohydrate constituents were not considered to be nutritionally important. A manuscript presenting these findings has been prepared for publication.

B. Properties Related to Quality and Consumer Use of Food

1. Organic acids, carbohydrates, and fruit quality. Research has been completed relating changes in composition and eating quality occurring as the result of home freezing of strawberries, raspberries, peaches, and cantaloups grown in 1961, 1962, and 1963, to variety and degrees of ripeness. Determinations included soluble solids, titratable acidity, pH, fructose, glucose, sucrose, citric acid, malic acid, quinic acid, total pectin, protopectin, water soluble pectin, shear force, color difference meter readings, and panel evaluation of color, texture, and flavor. Determinations were made both on the fresh fruit and on fruit frozen and stored at -10 to 15° F. for 6 months. Data are being evaluated and reports of the research are being written.

2. Constituents in cells and cell walls of fruits related to texture. Research was initiated to obtain microscopic and histochemical information concerning the constituents of cells and cell walls in fresh and frozen fruits and their possible influence on texture of fruit varieties. Greater knowledge of minor constituents, such as lipids and proteins, and their relation to major polysaccharide constituents would lead to more informed selection of varieties and improvement in methods for freezing to retain a firm, yet tender texture of the fruit.

3. Food distribution programs. Revision of the publication "Quantity Recipes for Type A School Lunches" (PA 631), was completed in cooperation with the Agricultural Marketing Service and the Fish and Wildlife Service, U. S. Department of Interior. This recipe card file provides 324 quantity recipes or variations and other information needed in preparing Type A lunches in schools participating in the National School Lunch Program. Recommendations on preparing, storing, and handling a wide variety of fruit, vegetable, cereal, dairy, meat, and poultry products were updated to take into account recent research findings and technology. Recipes were tested and evaluated, and all formulas and yields were recalculated in line with the 1964 revision of PA 270, Food Buying Guide for Type A School Lunches.

C. Food Consumption and Diet Appraisal

1. Planning for proposed nationwide survey, households and individuals. A nationwide survey of household food consumption and of the food intake of individuals is scheduled for 1965. Plans have been developed for a survey that would provide at least 6,000 household schedules and 10,000 individual schedules in the spring of the year with smaller household samples in each of the three succeeding seasons. The information on the week's food use to be obtained from each household is similar to that obtained in 1955, except that information on home baking practices will not be requested and information requested on home food production, home canning and home freezing will be reduced to allow interview time for questions on the food intake of individual members of households.

In preparation for the proposed first nationwide survey of the food intake of individuals, data obtained by recall on the 1-day intake of food from nearly 550 individuals of all ages in Washington, D. C. during June and July 1963, have been studied in relation to two controversial issues that concern collection of data. The survey findings indicate that for this group: (1) The nonresponse rate on food intakes from individuals is not influenced by taking a schedule on household food consumption first in comparison to taking none, nor is it influenced by taking a schedule on food intakes from half in comparison to all individuals in the family; and (2) homemakers report the amounts of food eaten by family members in terms of their individual servings far more often than as proportions of household amounts. Tabulations of the Washington data also are useful as a pretest for tabulation of the nationwide survey.

2. Effects of food distribution programs on diets of needy families. A survey of the food consumption of more than 800 households that were not participating in the food stamp program in St. Louis was made in May and June 1964 to determine the relation between usual family food expenditures and payments required for food coupons. Homemakers were asked also why their families did not participate in the program. Results of the analysis will guide the Department in revamping the St. Louis stamp program to make it more acceptable to eligible families and yet keep it within the limits of the program. Because of interest in the nutritional quality of food consumed by low-income families, an assessment may be made later of the dietary levels of these families. This is the sixth in a series of USDA food program surveys made in cooperation with the Marketing Research Division, ERS to assist the AMS to administer the food stamp and direct distribution programs.

3. Food consumption of the rural population in Spain (P.L. 480 research). A survey of the food consumption of the rural population in Spain has been initiated by the Spanish Ministry of Commerce under the cooperative sponsorship of the Economic Research Service and the Agricultural Research Service, using P.L. 480 funds. The study will provide information needed in appraising potential markets in Spain for U. S. farm products and should yield information useful to U. S. authorities on efficient ways of improving nutrition in low-income areas. The Spanish Ministry of Commerce expects to obtain much useful information on which to base a program for improving the diets of rural families, especially through better distribution of food. Information on food consumption, income levels, and related socio-economic characteristics has been obtained from about 1,200 rural families in 6 major regions of Spain. In summarizing the results, emphasis is being placed on (1) determining the nutritional shortages among these rural families at different income levels in the different regions, and (2) computing income elasticities for different foods as well as total food consumption.

4. Effect of socio-economic factors on food intakes of individuals. Under a cooperative agreement with the Minnesota Agricultural Experiment Station intensive analysis of data previously collected showed 1) that intakes of vitamins A and C from food by 9- to 11-year-old Ohio children increased with family income, and at each income level, a larger proportion of urban than farm children had food that provided recommended amounts of vitamins A and C, and 2) that children whose food was supplemented by vitamin A and C concentrates in general did not need them as they were in "nutrition conscious" families that provided the children with foods that were high in these nutrients.

5. Nutritive value of national food supply. The nutritive content of the per capita food supply is calculated each year from estimates of quantities of foods consumed (retail weight basis) as developed by the Economic Research Service. This series, which begins with the year 1909, is being completely revised to incorporate newest estimates of per capita consumption, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

A survey conducted by the Bureau of the Census for the Consumer and Food Economics Research Division has provided information for the years 1957-61, on quantities of enrichment ingredients supplied to processors to fortify flour and cereal products. Through this program about one-third more thiamine, one-fifth more iron and niacin, and one-tenth more riboflavin are added to the Nation's diet than would be available if foods were not enriched.

For the first time, the enrichment survey was extended to include information on the quantities of ascorbic acid and vitamins A and D added to foods, thus furnishing a base line for future surveys. Currently the amount of ascorbic acid added to foods would be enough to increase the level in the per capita food supply by 5 percent. The contribution from synthetic vitamin A is 7 percent of which 6 percent is added through margarine. Vitamin D is not at present included in nutrient estimates.

6. Household practices in home freezer management. Recording forms and questionnaires for obtaining data on management practices of urban and rural home freezer owners were pretested and necessary revisions were made in preparation for data collection among households in Fort Wayne, Ind., and a nearby rural area. Information will be obtained in two seasons on the kinds, amounts, sources, prices, and turnover rates of frozen foods stored in the home. Such data will provide information needed to develop guidance materials for improved management of home freezers.

7. Development of food budgets and other basic data for food and nutrition programs. Interpretation of nutrition research findings and their application to practical problems has continued as part of an ongoing program to assist nutritionists, teachers, health workers, and other leaders concerned with applied nutrition programs or nutrition policies. Information developed under this program is provided to many groups both within and outside the

Department working on practical food programs, on questions relating to nutritional requirements, food consumption, nutritional importance of specified foods, and on nutrition education. Increased emphasis has been given this year to opportunities for disseminating information to the public through TV and radio, the press, conferences, workshops, and the Department's Food and Home Fair.

Food budgets at different cost levels for individuals and families are priced quarterly for publication in Family Economics Review as a continuing service to welfare workers, extension agents, and others needing this information. For example, in June 1964, the cost of one week's food for a family of four including 2 school-aged children, was estimated to be \$24.40, \$32.80, and \$37.40, respectively, for the low-cost, moderate-cost, and liberal plans.

The food budgets published in Home Economics Research Report 20, "Family Food Plans and Food Costs," have been reexamined in the light of revisions in food composition data (Handbook 8, revised) and in recommended dietary allowances of the National Research Council. Some modification in food quantities was needed for certain individuals. This has necessitated revision of food plans and their presentation in technical and popular publications, including Agriculture Handbook 16, "Planning Food for Institutions," now being readied for publication. The "Food Purchasing Guide for Group Feeding," formerly a part of Agriculture Handbook 16, is in the final stages of editing for publication as a separate handbook.

All other existing guidance materials for nutrition programs were reviewed in light of the changes in recommended dietary allowances and in food composition data. Some publications have been revised; others will be updated for the next reprinting.

Nutrition Program News, a bimonthly periodical prepared for members of State nutrition committees and other community nutrition workers provides one channel for disseminating pertinent information about Federal programs and for reporting nutrition activities in the States. Issues this year included such diverse subjects as a report of the World Food Congress held in Washington, June 1963, "Labels on food products--the protection they give," and "Nutritional fitness for teenagers." Assistance to workers in nutrition programs has been provided also through consultation and program participation by staff nutritionists.

PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

Nutrient Value of Food

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III. MARKETING AND ECONOMIC RESEARCH

MARKET QUALITY

Market Quality Research Division, ARS

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition these products vary widely at harvest in the characters that determine market acceptance. Practical objective measurements of quality would greatly assist in standardization and grading procedures, and the development of instrumentation for this purpose increases the chance for automatic quality sorting on a commercial basis. Additional information is needed on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Continued research is needed with transportation equipment and services as affecting ultimate quality of the product in the market.

Dried fruits and tree nuts are subject to insect infestation while drying in the field, during storage while they await processing, in the processing plant, and in marketing channels until they reach the final consumer. Research is needed to develop more effective measures for preventing insect infestation all along this line. Emphasis must be given to finding methods that will keep both insect contamination and pesticide residues at minimum levels.

USDA AND COOPERATIVE PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, and food technologists. The research includes both measurement of quality and maintenance of quality during the period between harvest and consumption. Locations include laboratories at Beltsville, Maryland; Wenatchee, Washington; Fresno, California; Raleigh, North Carolina; Chicago, Illinois; and Belle Mead, New Jersey; and contract work at Corvallis, Oregon with the Oregon State Experiment Station. Research on gamma irradiation of fruits and vegetables has been under way at the Fresno laboratory with some financial help from the Atomic Energy Commission. Cooperative agreements and limited contributed funds were in effect with the California Strawberry Advisory Board. P.L. 480 supported research is under way in England on the effects of modified atmospheres on the physiological processes of apples; in Finland on fungicide residues and postharvest effects on fruits as related to time and rate of spray application; and in Italy on the principal rots of apples and pears.

There is a continuing program at Fresno, California, involving entomologists in applied research on the prevention of insect infestation and pesticide residues in dried fruits and tree nuts. The work is conducted in cooperation with California State and County agencies and with several industry groups. In addition to the direct work at Fresno, much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dried fruits and tree nuts.

Federal effort in this program totals 19.0 man-years divided as follows: objective measurement of quality 2.9; quality maintenance in handling and packaging 1.3; quality maintenance in storage 3.7; quality maintenance during transportation 1.5; postharvest physiology 1.8; postharvest disease control 4.0; prevention of insect infestation 3.0 and program leadership 0.8. Research under P.L. 480 includes a 4-year project in Finland on chemical residues for a total of \$56,637 equivalent; a 5-year project in England on the biological effects of modified atmospheres for apples at \$67,031 equivalent; and a 3-year project in Italy on apple and pear rots for \$18,357 equivalent.

Work terminated during the period included: softening of brined cherries (MQ 2-16); temperature and fungicides on peaches (MQ 2-22); and sulfur dioxide treatment of grapes. (MQ 2-49) Line Project MQ 1-10, dealing with the fumigation of tree nuts, was discontinued because of the unavailability of sufficient personnel to conduct the work.

PROGRAM OF STATE EXPERIMENT STATIONS

Eighty-seven projects in twenty-eight States are devoted to market quality, research for deciduous fruit and tree nuts. These studies include research on sizing, packaging, cooling, storage, and handling as well as the determination of the effect of chemicals and packaging films on storage life, chemical changes, and quality of refrigerated fruits and vegetables.

There are two regional projects in this area of research. NEM-27 is entitled Post Harvest Physiology of Pomological Fruits and is concerned with the development of objective methods of measuring maturity, ripeness, and condition of fruits for fresh market and processing; with the establishment of principles most conducive to maintenance of high quality fruits during the post-harvest period; and with the investigation of physiological and biochemical processes occurring in harvested fruit. WM-26, entitled Consumer Purchase and Utilization of Selected Fruits and Vegetables in the Western Region, is designed to determine the factors affecting consumer preference, purchase and utilization of fruits and vegetables in fresh and processed forms; and to determine the quality and cost of selected fruits and vegetables available to the consumer in fresh and processed forms in retail stores.

Disease research includes numerous projects which indirectly bear a relationship to improvement of market quality. Examples of pathological research contributing directly to improved market quality of fruits and nuts in the marketing channel are California projects on post-harvest diseases of fruits and vegetables, products formed by fungi in rot of fruit, chemical control of post-harvest fruit and vegetable decays occurring in packinghouses, and post-harvest rots of peaches and other stone fruits in transit and storage; and New Jersey research on preservation of the quality of freshly harvested produce through the control of decay-producing organisms.

Total market quality research on deciduous fruit and tree nuts at the State stations is approximately 34.7 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Eastern Apples. A correlation of $r = .784$ was found between the readings with the light transmittance difference meter and the Magness-Taylor fruit pressure tester. Data used were mean values of 4 sample lots for each of 5 weekly harvests. The Automatic Fruit Internal Quality (IQ) Sorter was tested extensively with Golden Delicious, Stayman, Red Rome and Winesap apples. Low chlorophyll content was highly correlated with eating quality, as determined by a taste panel. Low chlorophyll fruits were slightly firmer than high chlorophyll fruits throughout the test. Comparisons of the Magness-Taylor pressure tester with the mechanical thumb on 5 varieties of apples showed significant differences between readings, largely as related to variety. Ripeness of the fruit, as related to instrument reading, is being determined by panel evaluation. (MQ 3-28)

2. Western Apples. The chlorophyll content in individual apples from a single Starking Delicious tree widens as the number of days from bloom increases. Considerable variation in the chlorophyll content of fruit from different trees was evident. There was less tree to tree variation in soluble solids and acidity; these being more closely associated with number of days from bloom. Chlorophyll content and flesh firmness were inversely related in fruit of early harvests. Separation of water-cored Delicious by light transmittance proved effective again this season and appears to be ready for commercial application. Water core disappeared from Starking Delicious apples more rapidly at 65° than at 31°F. but loss in quality was rapid at the higher temperature. (MQ 3-28)

3. Red Tart Cherries. Cherries sorted with the light transmittance difference meter showed sound, normal cherries within the 0-30 range. Three percent scalded fruits or 20% with other defects did not downgrade the frozen product. Scald results from bruising followed by an oxygen deficiency. Under these conditions the anthocyanin pigments migrate from the skin into the flesh resulting in the scalded appearance although the total anthocyanin remains constant. Bruised cherries held in air did not scald. Scald occurred

in bruised cherries in the commercial soak tanks with low oxygen concentrations. Limited tests indicate that pumping air through the soak tank may prevent scald. (MQ 3-27)

B. Quality maintenance in handling and packaging

1. Film Liners for Apples. Equipment and basic techniques were developed and numerous permeability tests made at 32° to 68°F. at Beltsville. Logs of gas transmissions rates were approximately linear to reciprocals of Kelvin degrees. The variation coefficient was 8.7 percent for film types. Identical samples varied 2.5 percent. Variations were greatest in plasticized films. Film diffusion temperatures averaged higher than ambient temperatures. Diurnal pressure effects were less than seasonal effects. Of 1900 film samples examined, 75 percent exceeded the stated gage, but 4 of 5 types averaged less than 2 percent variation. Physical changes, detectable by light frequencies of 1.8 to 12.5 microns, were serious in one film type. Some film liners deteriorated during prolonged apple storage. Film deterioration was most severe when the liner contained Delicious or Stayman Winesap apples indicating that apple volatiles may have been involved. The scald inhibitor, santoloin, used on some test fruit may also be responsible for film deterioration. Stress cracking of films occurred in 28 tests at 32°F. A light refraction test helped detect film flaws.

Pads containing 1 pound of hydrated lime within sealed polyethylene-lined boxes of apples held carbon dioxide within the container below 1% during 5-7 months storage at 32°F., compared with 4-7% CO₂ without lime. The oxygen content was also slightly less and the ethylene content higher, 4500 ppm vs 900 ppm without lime. The post-storage respiration rate of fruit was reduced 18% by previous storage in sealed liners without lime but only 10% with lime pads. Use of lime pads eliminated CO₂ injury (core flush) on Rome Beauty and Stayman apples packed in sealed polyethylene. (MQ 2-63)

2. Blueberries. Paper chromatography analysis of North Carolina-grown Wolcott blueberry fruits showed 14 amino acids; citric, malic, succinic, and quinic acids; and fructose and glucose. During ripening malic acid increased slightly while citric, succinic and quinic acids decreased. Amino acids did not change significantly. Fructose and glucose were present in nearly equal quantities at all stages of ripeness; both increased during ripening.

Decay in mechanically injured fruits increased as harvest maturity advanced, from about 17 percent of the green fruits to nearly 100 percent of the over-ripe fruits. Botrytis cinerea was the predominant cause of decay at 35°F. while Alternaria species predominated at 75°F. (MQ 2-94)

C. Quality maintenance in storage

1. Eastern Apples. Using 16 different controlled atmospheres for Red Delicious apples, the best overall results were obtained with 1 to 3% oxygen with or without CO₂. Below 1% oxygen (near zero) both injury and off-

flavors were evident. No typical scald symptoms occurred in any of the atmospheres with 1% or less oxygen. The firmest fruit after storage was from the near zero O₂ atmospheres; next from the 1% O₂ atmospheres and the softest fruit from the 3 or 21% O₂ atmospheres. Neither DPA nor hot water reduced scald appreciably in fruit stored at 5% CO₂ and 21% O₂. (MQ 2-63)

2. Plums. Laroda, Santa Rosa, and Nubiana plums were separated into groups differing in soluble solids, by flotation in a series of sodium chloride solutions. Wickson plums could not be sorted in this way because cavities of various sizes occur in the fruit. Since plums of less than 12% soluble solids do not ripen with good quality, this technique could be used to eliminate low quality fruit in some varieties.

Nubiana plums in sealed polyethylene lug liners, remained in better condition after 9 weeks' refrigerated storage than comparable fruit in vented liners. The fruit in sealed liners was firmer and had less decay than the fruit in vented liners. (MQ 2-12)

3. Sweet Cherries. Lambert cherries held for 25 days at 31°F. in atmospheres containing 10 percent carbon dioxide with 3 percent or higher oxygen, had fair quality after an additional 2 days at 70°F. The carbon dioxide retarded decay and acid loss in the cherries and preserved their fresh appearance. Results were comparable to those obtained with the use of sealed polyethylene liners. (MQ 2-99)

4. Grapes. After 3 months' storage, Emperor grapes that were hydrocooled had fresher stems, brighter red berries, and less weight loss than fruit cooled in air. Hydrocooled fruit was either fumigated in the conventional manner immediately after cooling or the SO₂ was applied in the hydrocooling water. Either method controlled decay as well as conventional fumigation in non-hydrocooled lots. No significant berry splitting occurred in hydrocooled Emperors, but up to 30% occurred in Thompson Seedless. The half-cooling time for packed grapes in a pilot-size hydrocooler was about 1 minute, varying slightly with flow rates of 10 to 40 g.p.m./ft.² of cooler area. (MQ 2-49)

D. Quality maintenance during transportation

1. California Strawberries. When a mixture of 1,1,1-trichloroethane and dichloromethane (SDV) was used alone at simulated transit temperatures it was as effective as carbon dioxide (CO₂) in reducing Botrytis decay of strawberries. In combination with CO₂, it was no more effective than the CO₂ alone, and in some experiments internal breakdown occurred in the SDV-treated berries. (MQ 2-83)

An air shipment of strawberries from California to New York with dry ice included, provided relatively high levels of CO₂ in the insulated container (17-37%) and the oxygen level did not fall below 7%. With the berries pre-cooled to only 49°F. before loading, transit temperatures were in the 50-55°

range. Berry condition was rated excellent on arrival and during 2 subsequent days at 60°. (MQ 2-83)

2. Simulated Transit in Nitrogen Atmosphere. Decay of red raspberries, held an average of 5-1/2 days at 50°F. was significantly less in an atmosphere of total nitrogen than in air. Atmospheres containing 0.25% or 1% oxygen with 99.75% and 99% nitrogen, respectively, were also beneficial in reducing decay. (MQ 2-71)

E. Postharvest physiology

1. Apple and Pear Scald. A 10-second dip in 2000 ppm diphenylamine (DPA) at 70°F. markedly reduced apple scald in tests at Beltsville with 4 varieties of apples. In two tests, heating the DPA suspension to 120° improved scald control as compared with the 70° dip but increased chemical injury. A 10-second dip in 500 ppm at 70° gave poor scald control on Delicious and Rome varieties but good control on Stayman apples. A 10-second dip in 500 ppm DPA heated to 120°F. was comparable to 2000 ppm DPA at 70° for all varieties. A 30- or 60°second dip in water at 130°F. provided scald control comparable to that obtained with DPA on Delicious and Stayman apples, but did not control scald on early picked Rome Beauty apples, and injured York Imperial apples.

Delicious and Winesap apples and Anjou pears were treated at Wenatchee with scald inhibitors in dips, waxes, and impregnated wraps and combinations of dips or waxes and wraps. Ethoxyquin applied in a wax, water suspension, or an impregnated wrap reduced the incidence of Anjou scald after 210 days storage at 31°F. Plain wax increased the amount and intensity of Anjou scald. Diphenylamine did not control scald on Delicious apples when applied in a wax, water suspension, impregnated wrap or combinations of the treatments but the same treatments produced excellent control of storage scald on Winesaps.

DPA residues were highest immediately after treatment in dip and wax treatments and decreased with storage time. The residues on fruits dipped in DPA and wrapped in DPA impregnated wrappers never exceeded 4.4 ppm. Residues on Delicious were generally lower than those on Winesap. (MQ 2-91)

Ethylene oxide at concentrations of 1.0 to 2.5% applied by gassing and by dipping soon after harvest caused severe injury to the 4 varieties of apples treated. The treated fruit was no firmer after 3 months storage at 32°F. than the controls. However, following storage, ethylene production was markedly inhibited in the treated fruit. (Exploratory Research)

2. Apple Respiration at Modified Atmospheres. These studies, undertaken at the Ditton Laboratory in England have shown that the respiratory quotient (CO₂ produced/ O₂ consumed) was much higher than would be expected from widely accepted concepts of substrates used in respiration, i.e. malic acid and sugars.

The extension of storage life conferred by controlled atmosphere storage was more closely approximated by oxygen uptake than by CO₂ production. As would be expected, respiration was reduced with lowering of temperatures, increasing CO₂ or lowering of O₂ levels, through the range of 54 to 32°F. When low temperature injury occurred, respiration rose to that equivalent of much higher temperatures. For reasons as yet unexplained, the respiration quotient rose as temperatures were reduced, and fell as its concentration of CO₂ in the atmosphere was increased. (E29-AMS-1(a))

3. Anjou Pear Scald. Anjou pears exposed on the tree to almost 300 hours below 50°F. in the 2 weeks just before harvest developed as much scald during storage as fruit exposed to temperatures continuously above 50°. These results did not confirm the hypothesis proposed by other work that high temperatures prior to harvest predispose fruit (apples) to scald. Santoquin (ethoxyquin) as a dip or in wraps gave excellent control of Anjou scald during each of two storage seasons; diphenylamine dips or wraps did not. Treatment with Santoquin after several months of storage did not provide scald control. Gas chromatographic analyses show volatiles to be similar in quantity and quality in scalded and non-scalded pears. Chlorogenic acid and catechin in the skin of Anjou pears decreases more in those treated with Santoquin than in non-treated. (MQ 2-66)

4. Lenticel Spotting of Golden Delicious Apples. A severe type of injury, characterized by a halo of discolored tissue around the lenticel, was found in Golden Delicious apples which had been packed and stored with urea-formaldehyde resin impregnated in paper. Similar injury had been found last year in pulp trays containing the same resin. Pulp or plastic trays without the urea-formaldehyde resin caused no significant injury. (MQ 2-72)

F. Postharvest disease control

1. Forecasting Storage Diseases of Apples. Ten grower lots each of Delicious and Winesap apples were washed in a fungicide (sodium-o-phenylphenate) and held at 70°F. in polyethylene bags at Wenatchee. After 21, 28 and 35 days decay, mostly blue mold, ranged from 1 to 3 percent. One lot of Winesaps developed 52% storage scab after 35 days. In samples of comparable commercial lots of fruit examined after 210 days in cold storage, blue mold decay ranged from 0 to 3%, while storage scab in the single lot of Winesaps was 46%. (MQ 2-67)

2. Grapes. Continuous exposure to ozone (1 ppm) in a commercial grape storage was not effective in controlling Botrytis rot in Emperor grapes during 2 months' storage at 32°F. Grapes initially fumigated with 1 percent SO₂ and then held in an ozone-treated room had approximately 2/3 as many decayed berries as those without the initial SO₂ treatment. Grapes fumigated in the conventional manner with SO₂ (initial plus weekly fumigations) had only 1/6 as much decay as those treated only with ozone. (MQ 2-102)

3. Blueberries. Dips in sodium salt of dehydroacetic acid solutions at 0.1 to 1.0% or in 2-aminobutane at 1.0% concentration were ineffective for reducing postharvest spoilage of blueberries. Hot-water treatments (5 minutes at 120°F., 2 minutes at 125°, or 1 minute at 130°) reduced decay over non-treated lots but caused some heat injury particularly in late-picked fruit. Hot-air treatments at high relative humidity also reduced decay and caused less injury than hot water. (MQ 2-45)

4. Strawberries and Raspberries. At Beltsville, heated air at high relative humidity or a 0.4 percent solution of dehydroacetic acid reduced postharvest decay of raspberries and strawberries as compared with wet and dry checks during 4 days holding at 60°F. Heated air at relative humidities below 70 percent did not reduce decay. Hot water (110°) dips injured strawberries, but 125° dips for 1 to 2 minutes effectively reduced raspberry decay. (MQ 2-104)

Strawberries were treated at Fresno, California with heated air at 100 percent relative humidity for periods up to an hour. In two experiments decay was reduced from about 25% to about 4% by exposure to 111°F. for 1 hour, but slight injury to the berries was also observed. (MQ 2-83)

5. Cranberries. Cranberries from one location in Massachusetts, which were dipped in hot water developed significantly less spoilage after 4 months' storage at 38°F. plus 7 days at 70° than did non-treated berries. Spoilage was not reduced in berries obtained from 2 other locations. (MQ 2-45)

6. Gamma Radiation Treatments. Pasteurizing doses of gamma irradiation extended the market life of strawberries and two varieties of figs by several days through reduction of decay, without apparent impairment of fruit quality. Brown rot, but not Rhizopus rot, of peaches and nectarines was controlled; the peaches softened during irradiation and subsequently developed more red color, but less flavor than the controls. Radiation inhibited blue coloring of plums and increased softening of the fruits. Low doses inhibited ripening of pears by several days, but ripening was abnormal. Irradiated apples were softer, more shriveled, and had less flavor than the controls following storage for 3 to 6 months. Individual varieties of peaches and figs responded quite differently to radiation. Water on the surface of peaches during irradiation caused spotting of the skin. Fruit maturity within the limits of these experiments did not affect the responses to radiation.

Decay of inoculated grapes was substantially reduced by irradiation before the infections had become established. However, the effectiveness of a given radiation dose was reduced as the concentration of spores on the grapes increased. Established fungal infections were more resistant to radiation than spores, and infections became increasingly resistant with age. Similar increases in resistance of infections as they developed were observed in oranges. In general, the effectiveness of a given radiation dose decreased as the number of cells to be inactivated increased, whether the cells were in the form of spores or mycelia. This work will be terminated upon completion of the report. (MQ 2-82)

7. Radiation on Pathogenicity of Fungi. Forty-four mutants of Penicillium expansum were tested for their virulence, using Jonathan and Red Delicious varieties of apple. Only those mutants requiring methionine were able to invade both varieties and an arginine-requiring mutant could not decay the Red Delicious variety. In vitro and in vivo supplementation studies indicated that inability to invade tissue was related to the relatively low concentration of the required amino acids at the site of inoculation. One heterocaryon (vegetative mycelium which contains a mixture of haploid nuclei other than the original type) and the corresponding diploid strain involving 2 avirulent methionine-requiring mutants, could cause decay. Mutant loci in 3 diploid strains could be assigned to 2 linkage groups by means of the parasexual cycle. In vitro tests with 7 antimetabolites and growth factor analogs for the inhibition of growth of Penicillium expansum showed none to be effective when compared with the fungicide dehydroacetic acid. (MQ 2-96)

8. Pesticide Residues. This P.L. 480 project in Finland on postharvest chemicals showed that CIPC and IPC (sprout inhibitors and fungistats) disappear rather slowly from stored fruits. The rate of disappearance increases with temperature in stored apples, plums and tomatoes. Postharvest application of CIPC, IPC, and captan (fungicide), indicate that captan improved the keeping quality of plums and ripe tomatoes but caused marked chemical injury to apples during storage. IPC and CIPC were effective for the reduction of postharvest decay in plums, ripe tomatoes, and apples but inhibited color development on plums and mature-green tomatoes during storage. Storage decay was increased in stored carrots with either CIPC or IPC applications. (E8-AMS-1(a))

9. Apple and Pear Rots. This P.L. 480 project in Italy, is concerned with the important fungi causing rots, their mode of entry, rate of development at different temperatures, and characteristic symptom. Useful information has been obtained on rots caused by spores of Botrytis, Penicillium, Gloeosporium, and Alternaria. Rate of decay as related to maturity of fruit at harvest and interval of storage before inoculation is also being obtained for several organisms. Detailed drawings and colored illustrations will be prepared as the project progresses. (E15-AMS-2)

G. Prevention of insect infestation

1. Insecticide Evaluation. Results from the first quarter of an extensive 1-year laboratory study of malathion as a protective treatment for raisins, almonds, and walnuts indicated that a dust treatment was superior to spray even though the amount of malathion applied was less. Young stages of the Indian-meal moth and merchant beetle appeared to be most susceptible, and adults of the dermestid beetle, Trogoderma inclusum, the most resistant of the insects tested. Protection of raisins against infestation seemed to be better thus far than that obtained through the use of malathion-treated drying trays. (MQ 1-15)

2. Insecticidal Control. A series of 9 dichlorvos thermal aerosol applications in 3 different wineries gave unintentional wide extremes of vapor concentrations, indicating the need for better control over rate of application and for more knowledge of factors influencing dosage-concentration ratios. All applications gave significant reductions in numbers of vinegar flies in the wineries, effective control lasting 3 to 12 days, with an average of 8. Mineral oil as the carrier gave a denser aerosol and had less objectionable odor than when diesel oil was used. (MQ 1-34)

In final observations on tests started in 1962, raisins stored for 1 year after being dried on malathion-treated trays contained fewer living insects and showed less increase of insect fragments than did those dried on untreated trays. Processing greatly reduced the amount of foreign material in the raisins and generally reduced the amount of malathion residue. There was an interesting shift in predominant insects during the last 2 or 3 months the raisins were in storage. The raisin moth was most abundant during the first 9 months but almost disappeared during the last 2 months when the Indian-meal moth, saw-toothed grain beetle, and dermestids appeared. (MQ 1-34)

In supplemental observations it was found that raisins contained significant amounts of malathion after drying 1 week on treated trays and the malathion reached the maximum amount after 2 weeks. From 60 to 90 percent of the malathion was in the outer "waxy bloom" of the raisins. Significantly fewer insects were found in raisins from carefully picked, uninjured grapes than in those from typical commercial picking. (MQ 1-34)

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TRANSPORTATION AND MARKETING FACILITIES
Transportation and Facilities Research Division, ARS

Problem. Returns to producers and prices paid by consumers for horticultural crops are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facility designs are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes, citrus fruits, deciduous fruits, vegetables, and other horticultural crops. Such improvements are needed at both shipping points and terminal markets. They would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing costs, expand consumption, and reflect greater returns to producers.

It costs about 8 billion dollars a year to package food products, but without shipping containers and various other types of packages it would be impossible to move farm products efficiently from the widely dispersed areas or production through our complex marketing system to millions of consumers. New or improved packages and containers must be developed and evaluated to do this job more effectively. Continuing changes characterizes the American marketing system. In protecting, distributing and selling perishable agricultural commodities, packages and containers must respond to a number of marketing system changes. The job of the research program in this area is to see that packages and containers keep pace with changes in the marketing system and reduce the cost of handling, transporting and storing agricultural commodities. It also seeks to improve service to consumers, promote greater sales of farm products, and increase the income of producers.

The cost of transporting farm products to market in 1963 was 5 billion dollars. Cost of transporting supplies used in farm production totaled more than one billion dollars. Further, costs of other marketing and production functions, such as loading and unloading vehicles, packaging, storage and processing, also are affected by the efficiency of transport. These costs are important to the American farmer because they influence the return he receives from the sale of his products. They also are important to the American consumer because they influence the price he pays for his food. Therefore, the prosperity and efficiency of our entire agricultural industry and the economic well-being of the American consumer are closely tied to the efficiency of our transport system.

USDA AND COOPERATIVE PROGRAM

This is a continuing long-range research program covering the development of improved work methods, techniques, devices, operating procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing deciduous fruits. Deciduous fruit research is carried on by the Wenatchee, Wash., and Athens, Ga., field offices and by the Hyattsville office; in both laboratory and commercially owned facilities; in cooperation with the Washington and

Georgia Agricultural Experiment Stations, and the Market Quality Research Division. The Federal professional man-years involved were 3.0 for F.Y. 1964.

Work on consumer packages and shipping containers is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages, master containers, packing materials, and shipping containers for agricultural products; (2) evaluate them from the standpoint of cost of materials and direct labor to pack, and their ability to reduce product damage and increase product salability; (3) determine at which point in the marketing system packaging can be done most effectively; (4) improve the efficiency of packaging methods to cut costs; and (5) investigate the needs for and benefits of container standardization and simplification. The program is carried on in cooperation with experiment stations and industry in California, Oregon, Washington, New York, South Carolina; at branch field stations in Orlando, Florida; Fresno, California; and Yakima, Washington; in other main producing areas, and in the principal terminal markets. The Federal professional man-years involved were 2.9 in F.Y. 1964.

The economic-engineering research in this field is a long-range program. It seeks to develop improved transport facilities, equipment and techniques and more efficient ways of using them in transporting agricultural products and supplies. It is interdisciplinary in nature, drawing upon the training and experience of economists, mechanical and industrial engineers, marketing specialists and various other scientists. All the work is done with the cooperation of transport firms, transport and refrigeration equipment manufacturers and lessors, trade associations, State universities and experiment stations. Field studies are carried out throughout the U.S. and on overseas shipments. Only one field station, Orlando, Florida, is permanently maintained to support this research program. Part of the work is accomplished through research contracts and cooperative agreements. At the present time work is underway in each of the following fields: (1) transport equipment, (2) refrigeration equipment and techniques, (3) better utilization of transport equipment and techniques, (4) loading methods, including unitized loading, (5) development and evaluation of pallet containers, and (6) overseas transport. The Federal professional man-years involved were 1.9 in F.Y. 1964.

PROGRAM OF STATE EXPERIMENT STATIONS

Research concerned with the economics of marketing at the State Agricultural Experiment Stations is reported under the appropriate areas of work of the Multiple Use Report, Marketing Economics Division. Likewise, research dealing with facilities and transportation conducted by the agricultural engineers at the State Experiment Stations is reported in the Multiple Use Report of the Agricultural Engineering Division, Areas 4, 5, and 9. Related research in food science and technology is reported in the Multiple Use Report of the Utilization Research and Development Divisions.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Handling and Packing

This research is directed toward the development of more efficient work methods and equipment for handling, washing, sorting, sizing and packing apples. It includes a study of the impact of electronic color sorting of apples on related packinghouse operations and an evaluation of presizing and presorting apples in commercial storages and packinghouses.

1. At Wenatchee, Wash., research was directed toward determining costs of the electronic color sorting of apples, observing the action of the fruit as it passed through the machine to make determinations of the bruising incurred by fruit from the color sorter, measuring operating capacities for 6- and 4-row scanners, and making preliminary observations of manual sorting operations of apples presorted for color.

Although the sorter does an excellent job of separating both red and yellow varieties of fruit by degrees of surface color, the high cost of the unit is prohibitive for any but the largest packinghouses. Moreover, apples, as currently handled by the electronic color sorter, are subject to additional bruising. Although it was found that the color sorter does result in a higher percentage of Extra-Fancy grade apples in any given lot being delivered from the sorting table to the packers, the number of sorters still necessary to inspect for surface defects leaves some doubt as to the economy of electronically presorting for color.

Research was conducted on determining the requirements for a unitized brush-sizer and preparing the designs for a prototype unit. The unitized brush-sizer is an entirely new concept of a fruit sorting and sizing line in which a single equipment item; instead of three separate units; is used to sort, size, and brush fruit. Design drawings were completed, specifications written, and bids obtained from equipment manufacturers for the construction and installation of this item of equipment in a commercial apple packinghouse for test purposes. A contract to construct and install the prototype brush-sizer has been let to a Wenatchee, Wash. firm and the unit should be ready for tests early in 1965.

During the design phase, a mock-up of the sizing section of the unitized line was built and the effectiveness of this method of dimension sizing was tested. These tests showed that sizing apples by this method was fully as effective as when conventional sizers are used, and the brush-sizer showed promise of even greater effectiveness. During the tests, some apple specimens were "run" on the sizer as many as 10 times with no indication of damage to any of the fruit. Peaches, apricots, pears, and plums were also sized on the unitized brush-sizer mock-up. The preliminary findings of these tests indicate that these fruit varieties can be sized satisfactorily, and, after properly adjusting the rotational rates of the brushes, damage to the fruit is nominal.

Work sampling studies of a re-sorting operation of fruit that had been sorted prior to storage indicate that sorters react to once-sorted fruit much the same as they do fruit which is being sorted for the first time; that is, they feel it is necessary to remove fruit at a fairly consistent rate from the sorting table regardless of the incoming fruit quality.

2. At East Lansing, Mich., under a cooperative agreement with the State Station, research was continued on the design of equipment which uses water as a medium for dumping, sorting, sizing and filling apples back into pallet boxes. During the report period special attention was given to a hydro-filling device and to evaluating bruising and sizing accuracy and efficiency for various speeds of the recommended submerged chain sizer. McIntosh, Red Delicious, Jonathan, and Golden Delicious apples were used in these tests. A final report, "Development of a Hydro-Handling System for Sorting and Sizing Apples for Storage in Bulk Boxes," was submitted by the Station in connection with the cooperative agreement, for publication by the Department. This report should serve as a guide for equipment manufacturers, storage and packinghouse operators, and researchers in the further development of hydro-handling systems for apples.

3. At Athens, Ga., research was initiated on handling and packing peaches in commercial facilities. Following a search of the literature on handling peaches, approximately 30 peach packinghouses in Georgia, South Carolina, and Florida and one equipment manufacturer in Georgia, were visited to inspect the equipment and facilities presently in use and to establish industry contacts needed for conducting field studies. Indications are that many existing facilities are not being efficiently utilized, but that a number of new facilities are being built or planned, and many existing packinghouses are being remodeled. In many cases, equipment replacement also is contemplated; all of which indicates the immediate need for research to provide guidelines for layouts for peach packinghouses and improved equipment.

Engineering studies were conducted in 15 peach packinghouses in Georgia and South Carolina. Data were obtained on facilities, equipment requirements and capacities, floor space requirements, layouts, work methods including crew sizes, and operating procedures. Based on these findings, the development of improved layouts for synthesized packing operations of selected sizes was started. The layouts will provide packinghouse operators with guidelines for making needed improvements.

Three methods of receiving and two methods of dumping peaches from field containers were studied. Time study and micromotion data were obtained on the following three methods of moving one bushel field crates of peaches from a truck to a temporary storage area: (1) Conveyor, (2) 2-wheel hand clamp truck, and (3) pallet and forklift truck. The two methods of dumping studied were manual and mechanical. These data have not been analyzed.

4. In the Hyattsville, Md. office, the first draft of the manuscript "Apple Packing Methods and Equipment," based on contract research completed several years ago, was completed and will be submitted to the Wenatchee, Wash. field office for up-dating. This report when completed will contain a description and analysis of methods and equipment for preparing apples for market; not including the sorting operation.

B. Storage

1. Cooling Rates. The purposes of this research, at Wenatchee, Wash., are to: (1) Measure and evaluate the cooling rates of fruits in storage and shipping containers in terms of container designs that properly protect the fruit, shorten the cooling period, and maintain the fruit at proper storage temperatures; and (2) develop improved handling, stacking, and storage practices.

Work was undertaken to improve the use of matched thermistors for measuring very low velocity (0 to 15 feet per minute) airflow to overcome difficulties encountered by this method in studies of cooling rates.

To provide needed variables for cooling rate studies to be made during the 1964-65 season, 12 fiberboard apple containers, six glued and six stapled, were obtained. Enlarged holes and extra holes, located to conserve the strength of the box and to provide the best possible ventilation, were placed in the ends of all but two of these boxes. Five different hole patterns were placed in the ends of each of two types of containers. Of these 10 containers, two special holes were located in each end, an oblong slot $1\frac{1}{2}$ inches down from the top of the box 4 inches long by 1 inch wide with rounded ends and centrally located, and three additional holes 2 inches in diameter. One of these located centrally in the end and one in each lower corner $3\frac{1}{2}$ inches in from the sides and $1\frac{1}{2}$ inches up from the bottom. Compression tests were then made to see what effect the holes had on the strength of the boxes. There was very little effect on the box strength by the holes and the stapled boxes were slightly stronger than the glued ones.

A cooling study run on a new type of telescoping fiberboard container or lug for cherries showed that the cooling rate of the cherries packed in the lugs was not fast enough to allow the packing of warm cherries direct from the field and then expect to cool them sufficiently overnight for shipment.

2. Refrigerated Storage. The objectives of this project at Wenatchee, Wash. are to: (1) Investigate airflow and distribution methods, patterns, and rates in refrigerated fruit storages to determine and evaluate the influence of these factors on cooling fruit and on bringing it to optimum storage temperatures; (2) determine and evaluate heat gains through various structural features of fruit storages and make suggestions for improved designs; (3) redesign storage houses for the most efficient handling and storage of fruit in pallet boxes; and (4) evaluate hydrocooling of apples before placing in storage.

Studies of air doors installed in storages in the Wenatchee, Wash., area, made in cooperation with personnel of the Environmental Control Division, U. S. Naval Civil Engineering Laboratory, covered air door construction, airflow patterns, and operation. Operators of cold storages having air doors agreed as to the efficiencies gained by the removal of conventional doors under the present system of handling fruit in and out of the storages with industrial lift trucks.

A study of air temperatures and air distribution in one storage stacked full of pallet boxes of apples including the aisles showed a temperature variation of 5.2° F. throughout the room. Previous studies of this same storage with normal load and the aisles free of pallet boxes showed a temperature variation of only 2.7° F., which indicates how overcrowding can disrupt the airflow patterns.

In a study at another storage, thermocouples placed in the center of an apple in a packed box of apples at six locations throughout the room showed from readings at the two-week storage period that the temperature of the fruit at two locations was 37° F. A check of the airflow pattern showed that the air was being improperly distributed. Plywood baffles were placed at several locations to direct the air into the warm area and within one week the core temperature of the fruit had dropped to 32° F.

A new method of applying 4 inches of styrofoam insulation to tiltup concrete walls was developed and tried on a recently constructed storage. The styrofoam panels were laid out on the previously constructed concrete floor, then the concrete wall poured on top of them. When the concrete had set, the wall section was lifted into place in a vertical position with the insulation adhering to the concrete wall section. The striking feature of this method of construction is that no adhesive is used between the insulation and the concrete wall section. A natural bond occurs between the poured concrete and the styrofoam insulation. This method saves much labor in applying the insulation and is much easier and cheaper. As this method does not use a vapor barrier, some trouble with moisture infiltrating the insulation may occur.

After studying in detail USDA Circular No. 740, "Cold Storage of Apples and Pears," with the idea of updating it, it was decided in light of new developments and practices to prepare a new report on cold storage operation.

As a service to Washington State University Extension Service, personnel collaboration was given in the preparation of the bulletin E.M. 2344, "Instruments for Measuring Cold Storage Temperatures and Humidity," published by Washington State University.

Collaboration also was given in conducting a storage clinic which was attended by 45 storage operators and managers. Instruments for measuring humidity, temperature, and air movement were displayed and discussed. A 26-page paper was presented covering: (a) Refrigeration equipment and its operating

characteristics; (b) cooling capacity; (c) relationship of cooling rate to humidity control; (d) air volume and air circulation; (e) need for rapid cooling--removal of field heat; (f) fruit temperature in relation to storage life; (g) humidity control and atmospheric condition that effects apple quality in storage; and (h) rates of cooling as effected by containers and stacking methods. Other research personnel cooperating with the clinic discussed: (a) Segregating harvest maturity; and (b) harvest maturity for long storage.

To improve storage management, a special effort was undertaken in 1961 with one storage operator by installing thermocouples in his storage room to show temperatures throughout the room. Humidity conditions were improved by constant checking. The results from the 30,000 packed boxes of apples stored in the room the first season were so encouraging that other operators have applied the same principles. By 1963 there were roughly 400,000 boxes of apples held in special storages similarly equipped and managed. Over 750,000 boxes of "special storage" apples are planned for the 1964 season and five additional houses are studying their facilities in anticipation of converting to special storage.

Experience to date indicates that "special storage" involves three factors: (1) Apples must be picked at optimum maturity; (2) once picked the fruit must be cooled quickly and stored at 30° to 31° F.; and (3) humidity must be kept high (above 85%).

3. Controlled Atmosphere Storage of Apples. Work on this project is designed to develop improved methods, techniques, equipment, and facilities for the controlled atmosphere (C.A.) storage of apples in the Pacific Northwest, and is in cooperation with the Market Quality Research Division.

In a test made to determine if there would be any significant difference in the cooling rates, four thermocouples were placed in each of two C.A. storage rooms, one using the Tectrol (Whirlpool Corp.) system of C.A. and the other conventional C.A. using a caustic scrubber to remove excess CO₂ from the storage room air. Even though Tectrol C.A. continually blows warm air into the room, temperature curves indicated that the two rooms cooled at the same rate and held their temperatures well, which was an indication of ample refrigeration in each room. Humidifiers were placed in each room to keep the relative humidity above 95 percent. Some difficulty was experienced when the rooms were opened in May. Excess moisture had run down through the stacks of boxes of packed fruit and frozen making it necessary to chip away the ice before the stacks of fruit could be removed. As a result it was necessary to replace the outer covering or telescoping lids on many boxes. The study of these two C.A. rooms indicates that there is no distinguishable difference in the fruit when removed from the rooms if the temperatures and humidity are held relatively the same.

C. Cooling

This research is designed to develop improved methods, equipment, operating practices, and techniques for use in existing or new facilities for more efficient cooling of deciduous fruits.

At Wenatchee, Wash., work on this project consisted of studying the effect of hydrocooling of apples and the overall operation of a cold storage room during a hot season. The hydrocooler used in the test, was approximately 8-feet wide and 90-feet long. Apples were elevated into the hydrocooler from a submersion type water dumper by elevating rollers, floated the length of the hydrocooler, and then elevated onto brushes and then on through the sorting, sizing and packing line. The length of time the apples were in the hydrocooler varied according to the receiving load but averaged about 16 minutes. During that period the apple temperature was reduced about 16 degrees, or about 1 degree per minute.

The hydrocooler, which handles from 3,000 to 4,000 field boxes of fruit per day, could not handle all the apples as fast as they were received from the orchard during the 1963 tests. The boxes of apples that could not be immediately hydrocooled were placed directly into cold storage to be packed at a later date. Using this method the storage was able to maintain good cooling temperature at all times. Most storages in the area at the same time were having trouble in keeping the temperatures of their rooms low because of the large volume of fruit being received per day and placed into the storages.

One commercial storage house installed a hydrocooler for cooling cherries directly from the field. The cherries were first sorted and sized. The fruit went into the hydrocooler from the sizer. From the hydrocooler the cherries were packed in lugs and moved directly into cold storage. Tests show this type of cooling has the advantage over air cooling in that the stems do not lose moisture during the cooling process and retain their green appearance. The advantage of this method is that all the field heat is quickly removed from the fruit before it is packed and, as a result, should have a longer shelf life.

At Athens, Ga., convective heat transfer coefficients from the surface of Golden Delicious and Jonathan apples to air were measured at approach velocities of 300, 500, 800, and 1,150 feet per minute. Experimental coefficients were compared with theoretical values computed at each of the respective approach velocities. Positive correlation coefficients between theoretical and experimental were 0.971 for the Jonathan and 0.732 for the Golden Delicious. The chief value of these results lies in their verification of close surface temperature measurement. The same procedure applied to a larger scale in bulk fruit enables the prediction of surface heat transfer parameters under conditions in commercial practice.

Tests were conducted to measure the temperature distribution within Golden Delicious apples when a single specimen was subjected to forced-air, in the laboratory wind tunnel, at air temperatures of 10° F., 15° F., and 20° F., and approach velocities ranging from 285 to 1,155 f.p.m. After 30 minutes of cooling with air at 10° F. approaching a 2.7-inch diameter apple at 490 feet per minute, the average temperature on the fruit surface was 29° F. Its mass-average temperature was reduced from 75° to 36° F. The mass-average temperature of a 2.8-inch diameter Golden Delicious apple was reduced from 75° F. to 42° F. in 30 minutes with air at 15° F. approaching the fruit at 490 feet per minute. These examples illustrate the effectiveness of air as a heat exchange medium in precooling certain products. The results substantiate findings with oranges at Gainesville, Fla., and point toward the possibility of more efficient use of air in commercial precooling operations.

A manuscript, "Hydrocooling Peaches" was prepared as a popular version of Technical Bulletin No. 1292, "Thermal Characteristics of Peaches as Related to Hydrocooling."

Plans and specifications were prepared for the construction of an experimental, portable forced-air precooler for commercial-scale tests at packing-houses, and a contract was let for its construction.

D. Handling Grapes in Pallet Boxes

This research covers the development of improved work methods and equipment for handling Concord grapes at processing plants, and is cooperative with the Agricultural Engineering Research Division.

An analysis of data for in-plant labor and equipment requirements and costs for handling and transporting Concord grapes in experimental bins having a capacity of 650 pounds and on conventional lugs, revealed that the labor force for receiving 10,000 tons annually could be reduced from 16 to 3 workers, and that the saving in labor cost was considerably greater than the cost of the additional equipment that was necessary with the bulk handling method. These cost relationships were also computed for annual volumes of 20,000 and 5,000 tons with comparable savings at these volumes to grape processors through the use of bulk containers.

A section relating to methods and costs of handling grapes in processing plants by both the conventional and experimental methods was prepared for inclusion in a final report to be prepared by Agricultural Engineering Research Division, and completes the research in this area.

E. Handling and Packing Fruits and Vegetables on Terminal Markets

1. Tiering Devices and Equipment. This research by the Hyattsville office was directed toward reducing the cost of storing fruits and vegetables at the wholesale level by increasing the utilization of available storage space in wholesale fruit and vegetable warehouses. During the report year work in this area was confined to the editing and publication of Marketing Research Report No. 622, "Storing Fruits and Vegetables on Pallets in Wholesale Warehouses."

2. Loading Out Delivery Trucks. The purpose of this research was to evaluate and compare the relative efficiency of selected methods and types of materials handling equipment for order assembly and truckloading used by wholesale distributors of fresh fruits and vegetables supplying both affiliated and non-affiliated retail stores so as to reduce unit costs and minimize spoilage and waste. The research was cooperative with the Wholesaling and Retailing Research Branch. During the report period work in this area was confined to the editing and publication of Marketing Research Report No. 665, "Three Methods for Loading Out Produce in Warehouses."

F. Consumer Packages and Shipping Containers

1. Peaches. Newly developed fiberboard and combination fiberboard and veneer wirebound boxes were found to offer savings in materials and labor costs of about 20 cents per 3/4-bushel of peaches. Bruising has been reduced from 12 percent in bushel baskets to less than 6 percent in the new boxes. Six million boxes were used last year which saved over a million dollars in the cost of marketing peaches. The field work on developing shipping containers for eastern-grown peaches was completed during the 1963 peach season, and a report has been prepared for publication.

2. Apples. Export containers--Several different containers of apples were test-shipped from Hood River, Oregon to London, England in December 1963. The containers evaluated were (1) the conventional tray pack fiberboard box - 5 layers of trays, (2) a three-layer tray pack fiberboard box (the U. K. apple industry has recently shifted to this size container), (3) five-layer tray pack boxes made from wax impregnated fiberboard (some outer cover only, some inner body only, and some with both inner and outer cases made of waxed fiberboard), and (4) shrink-film wrapped 2-1/2 pound consumer packages packed in a two-piece, full telescope compartmented fiberboard box.

The Red Delicious apples arrived in London with less damage in the consumer packages and the smaller three-layer tray packs, than in the full size tray packs, whether regular or wax impregnated board was used. The wax impregnated fiberboard box showed no obvious advantage strengthwise.

Loose-fill boxes--Little difference was found among four different containers for loose-fill or jumble-packed apples to protect the apples. The test containers were: (1) The conventional two-piece bulk or loose-fill fiberboard box; (2) the conventional box with ply-veneer sides added for greater rigidity; (3) the conventional box with a 3/4" rigid spacer placed in the bottom of the body; and (4) a one-piece box with a 14" collarless web of 90-pound kraft paper laminated around the body. Bulging of the sides and ends of the box permitted the apples in all four test containers to settle in transit leaving head space and slackness. Greater box strength through better design or heavier board is still needed.

Master containers for bagged apples--An industry-developed compartmented master container was found more expensive than the conventional 2-piece full-telescope box because it held only nine 4-pound bags instead of ten 4-pound bags and because size of boxes prevented loading them in a standard rail car at the 40,000 pound minimum. The 2-piece full-telescope boxes also had greater stacking strength.

Cell and tray-packed Golden Delicious apples--More expensive waxed chipboard partitions did not show any improved performance over the unwaxed chipboard partitions for cell packed Golden Delicious apples. Chipboard partitions permitted more overhead pressure on the apples than the conventional double-face corrugated partitions, particularly as the length of time in storage increased. This was also true of the pulp trays tested, which rely on widely distributing the overhead pressures with staggered cups.

Evaluation of an experimental molded pulp deep pocket apple tray designed specifically for soft fleshed, bruise susceptible varieties such as McIntosh and Golden Delicious was continued. Improved tray and shipping container designs significantly improved the performance of this pack in a truck test shipment of McIntosh apples shipped from Maine to California. Successful development of this tray pack would save about 10 cents per box.

3. Pears. Four different packing patterns of placing consumer packaged Bartlett pears in shipping containers were tested, but no statistically significant difference in bruising or discoloration was found. A compartmented five-layer box, with vertical partitions, protected the consumer package appearance better than four-layer boxes with only horizontal layer pads. Packages stacked on their sides arrived in the worst looking condition because the pears shifted to one side of the tray, distorting both the film and the pulp trays.

During late March and early April of 1964, four commercial rail test lots of ripened D'Anjou pears were shipped from Yakima, Washington, to New York City. The purpose of these rail shipments was to determine: (1) The advantages and disadvantages of each of four consumer trays used for prepackaging pears; and (2) the advantages and disadvantages of three concepts of master shipping containers--a bulge and a flat pack with layer pads and a compartmented pack.

Differences in the consumer trays were found to be significant at the 99 percent level. One tray, designed specifically for prepackaged pears, was found superior to the other three trays that had been designed for apples and other round fruits. The longitudinal divider of the tray was the cause of most of the pear damage. Sharp ridges and gaps in these dividers need to be modified to reduce damage to pears.

The "bulge-pack" was found to be inferior for maintaining fruit quality as compared to the "flat-pack" and a compartmented box. The "flat-pack" master shipping container is recommended when pears are prepackaged and put in storage even though the pears settle and arrive slack in appearance, while the compartmented box is recommended as a shipping container for pears that are prepackaged for immediate shipment.

4. Grapes. Limited effort was devoted to: (1) Refining the design of a slit pyramid-shaped polyethylene bag developed by a package manufacturer. Experiments were conducted with the use of colored panels that would enhance the appearance of the grapes in combination with clear panels that would permit inspection of the grapes within the package. This package was also strengthened and its shape modified to fit grape bunches better; and (2) a preliminary evaluation of an extremely shallow consumer tray that provides a maximum of flexibility and visibility. These trays could be constructed of plastic or molded pulp. Initial results indicate that a complete film or mesh overwrap, rather than a band or sleeve wrap, is necessary for package strength. Preliminary test shipments of an industry developed full telescope fiberboard box in September 1964 showed some promise in offering good protection to the grapes and met with favorable trade reaction.

G. Transport Equipment

1. Thermal Rating of Refrigerated Trucks. This research is being conducted in cooperation with the National Bureau of Standards at the NBS facility in Washington, D. C. Its purpose is to develop a standard rating method to measure the thermal efficiency of refrigerated delivery truck bodies under conditions of 100° F. ambient, 50 percent ambient humidity, and 0° F. interior temperature.

Work was continued on the measurement of the rates of air exchange and the effect on load cooling caused by opening the door of a refrigerated truck. Preliminary tests were made using thermocouples, heat flow meters, and rapid response air flow probes designed and constructed at NBS. These instruments are used in conjunction with metered liquid nitrogen to maintain the steady-state interior temperature prior to the door opening and to restore the temperature immediately after the door is closed. Nitrogen from a self-pressurizing Dewar container is admitted to the interior through solenoid valves controlled by an air temperature multiple thermocouple grid. The heat load caused by the door opening can be determined by measuring the nitrogen required in excess of that required to maintain the steady-state temperature difference.

It is now anticipated that a final report will be issued during the next year.

2. Air Circulation in Refrigerated Trailers. The purpose of this research is to determine the most practical system for circulating cold air to obtain uniform temperature throughout a trailer load of frozen food. Previous tests have shown that temperatures at the front of a trailer near the cooling coils can be at 0° F. while other locations in the load may be several degrees above zero. This study seeks to find the best combination of blowers, air ducts, floor racks, and wall spacers to eliminate areas of high temperature. This is a cooperative program with the National Bureau of Standards being conducted at the NBS facility in Washington, D. C. Work during the reporting period was devoted to analysis and reduction of the large amount of data obtained from previous trailer tests. Preliminary analysis of the tests comparing continuous and cyclic blower operation indicated somewhat greater load temperature changes during refrigeration "off" periods under the 12° F. thermostat differential, compared to 4° F. and 6° F. when the blower was operated continuously. The thermostat sensing element was located in the return air stream near the evaporator coils and behind a bulkhead near the front of the trailer. The space forward of the bulkhead warmed faster than the cargo space when the blower was cycled off. With the blower under constant operation under the refrigeration "off" cycle, the forward space warmed more slowly, at approximately the same rate as the cargo space.

The 12° F. thermostat differential produced exposed cargo surface temperature changes of about 10° F. when the blower was cycled and about 8° F. when the blower operated continuously. Center cargo temperatures changed about 0.5° F. in each case. All tests were conducted with ambient temperatures of 100° F. and mean interior (return air) temperature of 0° F.

3. Liquid Nitrogen Refrigeration for Frozen Food Trailers. The objective of this study is to determine whether it is practical to use liquid nitrogen as a refrigerant in vehicles transporting frozen foods. Previous research has shown that liquid nitrogen and liquid carbon dioxide will provide 0° F. temperature for frozen foods. However, analysis shows that these expendable refrigerants are more costly than conventional mechanical systems. This project is being discontinued until costs of expendable refrigerants are reduced sufficiently to make their use economically feasible.

4. Multi-Purpose Transport Vehicles. Van Containers--A design concept for a multi-purpose van container was developed during the year. It was described in a press release which generated widespread interest among steamship lines, railroads, freight forwarders, trucking groups, transport and refrigeration equipment manufacturers. Meetings were held with representatives of these groups and several offered to make available their facilities and technical assistance in engineering, construction and testing of the prototype van. An application for public-use patent on the van is now being processed.

The container can be used to haul both frozen and nonfrozen perishable products and nonrefrigerated cargo. It also can be used to carry freight by rail piggyback, highway, water (fishyback), and perhaps by air in moving farm products to the consumers.

Trailers--Research was begun late in the year to develop practical, low cost, conversion systems by which conventional refrigerated trailers and dry cargo vans can be made dual-purpose vehicles for use in transporting bulk as well as packaged cargo. It is being carried out under a cooperative agreement with the Oregon Agricultural Experiment Station. Several trailers equipped with prototype conversion systems are now being tested in cooperation with several trucking firms in the Pacific Northwest. Initial results indicate that the rates of vehicle utilization are materially increased when the conversion systems are used. However, the project has not progressed far enough to obtain adequate data on vehicle utilization rates, operating costs, and revenue yields.

5. Improved Ventilated Piggyback Trailers. Research to develop improvements in rail piggyback trailers which will facilitate better product ventilation was continued during the year. Previous work showed that conventional highway trailers used for this service did not provide a flow of outside air through loads of perishables sufficient for adequate cooling.

Several trailers incorporating new ventilation systems were tested with shipments of watermelons from Florida to northern markets. One type van tested was equipped with adjustable scoops on the front ventilation doors to direct air into the van when hauled rear-end-forward on rail piggyback flat cars. Another type studied had under-floor scoops to direct air into the cargo area where the ram-effect forced it upward through the load and out the exhaust ports in the upper sidewalls of the van. The latter type trailer gave the best results. In paired tests the temperature of watermelons in a conventional van rose three degrees during transport while those shipped in the van with under-the-floor air scoops cooled 15 degrees. Additional work to develop further refinements in this system and to develop and test new equipment is being continued.

H. Transport Techniques

1. Pallet Containers for Transportation. All field work has been completed, the data analyzed and results evaluated on rail and truck shipments of apples in both expendable and reusable pallet containers of several different types. The initial report was extensively revised during the year. It is now being reviewed.

This research has shown that savings from using pallet containers of about 900 pounds capacity as compared to conventional 40 pound corrugated boxes range from 0.1 cents per pound, or about \$150.00 per carload for one trip to 0.2 cents, or approximately \$300.00 per car when the pallet containers are used for two trips. For some types of pallet containers greater

savings may be made by using them for three or more trips. The economies in pallet container usage in transport result from lower container, packing, handling, freight and protective service costs per pound of fruit.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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Handling and Packing Fruits and Vegetables on Terminal Markets

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Consumer Packages and Shipping Containers

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Transport Equipment

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COOPERATIVE MARKETING

Marketing Division, FCS

Problem: Farmers are expanding their use of cooperative marketing. There are constant changes in transportation, processing, and distribution technology, and in market organization and practices, and changes on the farm itself. In view of these developments, farmer cooperatives and other marketing firms require research results to perform both efficiently and effectively. Such research can assist farmers to maintain and strengthen their bargaining power, increase efficiency, and meet the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a major way for farmers to get maximum returns from their products in the current and rapidly changing market. Farmers own and control cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan, develop, and actually manage the specific marketing program and services that will yield the most for their members. Marketing cooperatives must know what the market demands. They must be able to compute the probable cost of different ways of serving the market. They must understand the possibility of major economies in a well coordinated joint sales program, and understand the methods and potentials of bargaining. Management must achieve minimum costs through improved organization, good use of existing plant and personnel, and the selection and use of new equipment and methods.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D.C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal professional man-years devoted to research in this area totaled 23.3, of which 1.2 were devoted to work on deciduous fruit.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. During the period of this report, contract research was performed by universities and colleges in Florida, Iowa, Louisiana, Montana, North Dakota, and West Virginia, and by one private research company.

PROGRAM OF STATE EXPERIMENT STATIONS

The State stations maintain a very broad research program in commodity marketing, the findings of which are valuable to cooperatives and to other marketing firms. There are at this time nine projects in eight States that deal specifically with cooperative marketing. Five projects are commodity oriented and deal with grain, tobacco, milk, livestock, and fruits and vegetables. These projects seek to find out how cooperatives are adjusting or might better adjust to changes in market structure and marketing practices. In some instances researchers are studying the success and failure of cooperatives and the organizational structure. One study of the history of major cooperative marketing associations in the State will be published as a book and will undoubtedly receive nationwide attention.

Because of the growing interest in the role of cooperatives in market structure, one State recently initiated a major project in this area. The project leader views cooperative enterprises as a structural dimension of farm markets. The objectives and operating procedures of cooperatives will be studied to see if they have a unique impact upon market conduct and performance. If so, this may have significant implications for Government policies and programs.

The total research effort on cooperative marketing in the eight States is 3.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Coordination of Marketing

Work continued on a study to determine problems and possibilities in further coordinating marketing of fruits by selected sales agencies. Guides will be developed for these agencies and other cooperatives interested in a coordinated marketing program.

B. Improving Cooperative Sales and Distribution Methods

Cooperative bargaining has been increasing among fruit and vegetable growers. Work has been initiated to (1) determine the current status of producer bargaining associations, (2) analyze common characteristics with regard to producer-market contractual and competitive relationships, (3) identify and evaluate factors responsible for success or failure of bargaining cooperatives, and (4) develop a framework and recommendations useful to groups interested in engaging in cooperative bargaining.

C. Potentials in Cooperative Marketing

Study continued on the present status and trends in cooperative marketing of these products. Research will include evaluation of the potential of cooperatives for increasing their operating efficiency and market effectiveness through integration, coordination, consolidation, expansion or other means.

D. Improving Organization, Financing, and Management Practices

Proposed cooperative fruit marketing and storage operations in Illinois and New Mexico were studied. Recommendations were made about organizational structure and plans of operation.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Hulse, F. E. 1964. Modern Service - Cooperative Style - or How Eight Growers Harvest Prunes. News for Farmer Cooperatives (Feb.).

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing program involving a series of studies to show: (1) Detailed analyses of marketing costs and margins in the various stages and channels in handling, processing, transporting, and distributing horticultural and special crops and related products; (2) comparative efficiency and costs of present agencies, organizations, methods, and practices in performing the services involved at each important stage in taking the crop products from farms to final users; and (3) the influences on costs and efficiency of such factors as grades and standards, methods of determining and maintaining product quality, and governmental regulatory and informational programs. On the basis of results of such studies, recommendations are made on possible means of increasing the efficiency of marketing, or increasing returns to growers, and of providing consumers with the choices they desire.

The Federal scientific effort devoted to this research in F.Y. 1964 amounted to 8.0 professional man-years.

PROGRAM OF STATE EXPERIMENT STATIONS

Much of the research at the State agricultural experiment stations on deciduous fruits and tree nuts relates to structure, practice, and competition. This involves a study of marketing practices used by farmers as well as firms in the trade, the interrelationships of new technology such as bulk handling to market organization and market power, trends in the number and size of firms, and the impact of market power technology and trends upon returns to the grower. Tests are conducted on the sales effectiveness of specific merchandising and promotional practices and the influence of packaging and shipping methods on the quality of the product. Some attention is given to the effects of types of advertising upon volume of sales. An important segment of research on these commodities relates to costs and efficiency in firm operations including assembly, processing, wholesaling and retailing. The firm structure is studied by operating segments so as to determine least cost combinations. One station has considerable research on prices and consumer demand but this is reported in another area. A total of 12.3 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Structure, Practices and Competition

1. Direct purchasing of fresh fruits and vegetables by retail chains has affected the structure of the wholesale market for fresh produce. A final report summarizing changes in the structure of 52 wholesale produce markets shows that direct purchases from shipping points by chains and affiliated groups increased from 12 percent of total market receipts in 1936 to 26 percent in 1958. During this time the number of produce wholesalers decreased by 15 percent. A study of further changes in the structure, organization and practices since 1958 in the Philadelphia wholesale produce market is to be made this year giving particular attention to changes in adjusting to the new food center.

2. This project, which has been completed, describes and evaluates the pecan industry, including market organization, trade channels, buying and selling practices, and methods of establishing prices. A survey of pecan shellers disclosed there were approximately 80 firms throughout the South and in St. Louis, Chicago, and Pittsburgh. Eight of the largest firms accounted for 48 percent of industry sales; 37 firms accounted for more than 90 percent of total industry sales. During 1961 the industry as a whole operated at only 35 percent of capacity--large firms operated at 60 percent, and small firms (mostly part-time businesses) operated at only 10 percent of capacity. Pecan growers were interviewed in six States--Arkansas, Florida, Georgia, Mississippi, New Mexico, and South Carolina. The total of 576 growers owned 370,000 pecan trees, or 13 percent of the trees listed in the 1959 Census of Agriculture. These growers planned to plant 38,000 more trees which would result in a 9 percent increase in the number of trees on the farms surveyed. Total sales of pecan trees by 49 nurseries increased from 370,200 in 1958-59 to 748,496 in 1961-62. Nurserymen expected further increases in sales through 1965. The pecan nursery industry is shifting to the West, where insect and disease problems are less than in the Southeast.

3. Technical and economic feasibility research into new methods of marketing peaches and nectarines was completed. Laboratory tests, trial shipments, and other quality evaluations showed that the quality of fruit during and after shipment was generally better with the tight-fill pack than with conventional place-pack methods. In addition, when compared with conventional place-pack methods, cost savings with the tight-fill pack could reduce substantially the level of labor and materials expense. Potential cost savings range between 18 and 25 cents per Los Angeles lug equivalent, depending on the size of plant and length of season considered. When these estimates are applied to the current volume of fresh peach and nectarine shipments, total annual cost savings to California growers and shippers could range between \$3 and \$4 million.
4. Red tart cherry growers and processors have faced large variations in total production. This variation has caused difficult problems in price negotiations between growers and processors. Analyses of factors affecting demand and price of cherries have been of assistance to the industry. This project is being terminated with the completion of analyses underway.
5. Changes in the structure of California fruit and vegetable markets are affected by transportation methods. A study of agricultural exemption, competition, and efficiency in the motor carrier industry disclosed that fruits and vegetables are the most important out-flow of exempt commodities originating in California. They accounted for 33 percent of 1961 tonnage of agricultural commodities transported across the California border and for 45 percent of the total ton miles. Trucks hauled about 30 percent of outbound fruit and vegetable shipments. Further research is being done on the probable effects of two alternative transportation policies--the elimination of agricultural exemption, or the extension of agricultural exemption to other modes of transportation.
6. The market feasibility of radiation pasteurization of fruits and vegetables is being evaluated for the Atomic Energy Commission as a part of the "Atoms for Peace" effort. A survey of shippers and wholesalers suggested that successful market introduction of radiation-pasteurized fruits and vegetables would depend on an effective public education program. Also, they estimated that they could afford to pay one-fourth of a cent per pound for radiation pasteurization except for strawberries where they could pay 1.75 cents per pound. An economic evaluation of radiation pasteurization for strawberries indicates that reductions in losses at current price levels should exceed estimated costs for radiation pasteurization. Sufficient technological data were not available for an evaluation for grapes and peaches.
7. The U.S. season average price of canning and freezing apples can be estimated by using data which are available early in the marketing season. Ninety percent of the variations in apple prices can be explained by the crop estimate, processed stocks, farm price of fresh apples, and a trend variable. Detailed results of this study were reported last year. This project has been discontinued.

8. Costs of packing and storing Michigan apples are being affected by changes in containers and in packing operations and particularly so with the increase in controlled atmosphere storage. In addition, there are 55 percent fewer apple packinghouses than there were in 1955. With this decrease in number there has been an increase in average size. Handling methods and packaging for Michigan apples also have changed. Over 70 percent of the Michigan apple crop is handled in bulk containers and about two-thirds are packed and shipped in polyethylene bags. Detailed studies of packing costs continue.

B. Margins, Costs and Efficiency

Data necessary to calculate marketing margins for fruits and vegetables have been maintained on a continuing basis since 1956. In the period 1956-1962, an average of 58 percent of the retail value of the fruits included in the study went to marketing. Of this, 34 percent went for retailing and 25 percent to the marketing functions between the shipping-point and the retail outlet. The remaining 42 percent was received by the growers and packers. During the 6 years, the retail spread increased 39 percent while the shipping-point to retailer spread declined slightly. In the same period, the grower-packer share decreased 21 percent.

C. Merchandising and Promotion

Expanding Markets for Peaches. Work carried out in cooperation with the Washington State Fruit Commission and Washington State University includes studies of market distribution of Washington peaches and a pilot test of the impact of various merchandising and promotional techniques on sales. Information on utilization and market distribution has been collected and analyzed and will be released through the Washington State Experiment Station. Findings indicate that about two-thirds of the peach crop is utilized for processing with the remainder sold fresh in nearby markets. Findings of controlled experiments designed to measure the effectiveness of alternative merchandising and promotional techniques were inconclusive because of unusual supply conditions during 1963. Further work is in progress to appraise the effect of retailer promotion and other factors on movement and prices received by producers.

D. Market Potentials for New Products and Uses

Market Acceptance of Explosion Puff Dehydrated Products. Exploratory research has been initiated on the application of the explosive puff dehydration process on blueberries, a development of EU, for pie baking. These berries rehydrate much more quickly than conventionally dried materials. Preliminary testing of the dehydrated blueberries in pie baking operations showed the flavor of the product was satisfactory. Problems revealed in use of the berries in testing such as level and type of starch used can easily be overcome. Further research is planned to obtain additional information on institutional market outlets which appear promising in terms of volume and types of products on the overall costs and efficiency of institutional operations. It is anticipated that the experience gained in the work on blueberries will be applied to other explosive puffed products, such as apple slices and potato pieces.

E. Transportation Cost and Services

Transportation of Fresh Fruits and Vegetables. This is a two-phase project dealing with interstate rail and highway transportation of California and Arizona fruits and vegetables and is concerned with the flow patterns and trends associated with rail and highway movement of fresh produce from California and Arizona to other States.

Striking changes have taken place in the use of highway and rail carrier service. Since 1951, the share of interstate traffic dispatched from California and Arizona shipping points by rail has dropped from 87 to 70 percent of total movement from those areas. The decrease has occurred primarily because shipments moving to points west of the Mississippi River --short and intermediate range hauls--have been tending to go more and more by truck. Trucks have increased their share of shorthaul traffic from 67 to 83 percent of the total and their proportion of intermediate range hauls from 20 to 66 percent. These shifts in shippers utilization of carriers reflect the motor carrier's ability to offer attractive rates and fast service. In many instances motortruck transportation has become so much more attractive than rail service that some users are willing to pay higher charges for truck service than they would have needed to pay for the nearest comparable rail service.

The second phase of this study, based on receiver interviews, is scheduled for completion by December 1964. Preliminary findings confirm those of the shipper survey. Receivers utilize rail and truck service to improve plant operations and to serve customers better.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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COMMODITY SITUATION AND OUTLOOK ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

Producers, processors, distributors and consumers need better information on supplies, production and consumption of farm products, and the effect of these and other factors on the prices of these products. Similarly, Congress and the administrators of farm programs need to evaluate alternative proposals to modify existing price support and production control programs in terms of their impact on production, consumption and prices received by farmers.

USDA AND COOPERATIVE PROGRAM

The outlook and situation program provides continuous appraisal of the current and prospective economic situation of deciduous fruits and tree nuts. Regular appraisals are supplemented by special analysis when needed. Results of these appraisals, findings of special analyses, and long-time series of basic data are published in the Fruit Situation, issued four times a year, and in brief reviews in quarterly issues of the National Food Situation and the Demand and Price Situation. A comprehensive analysis of the fruit and tree nut situation is presented at the Annual Outlook Conference. Presentations also are made at regional or State outlook meetings, meetings of farm organizations, and to various agricultural industry groups. Special studies are made to determine probable effect of proposed programs on supply, price and consumption of fruits and tree nuts. Basic statistical series on stocks, foreign trade, consumption, and price are compiled, improved and maintained for general use in statistical and economic analysis.

This work involves approximately .5 professional man-year in Washington, D. C.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend upon the U.S. Department of Agriculture for the yearly across-the-board commodity situation and outlook research. The State extension staff members supplement and adapt such research information to meet the commodity situation of their States.

Four States have projects that deal specifically with analysis of current price trends and prediction of future prices. There is increasing interest in longer range price prediction because of the growing specialization of farms, which make yearly enterprise shifts less common and less feasible, and which calls for large capital commitments over longer periods of time.

The total direct research effort in the situation and outlook area is approximately 1.7 professional man-years. While not designated as outlook research, much of the research conducted by the experiment stations and reported elsewhere contributes to improved understanding of price-making forces, which in turn improves market situation analysis and price forecasting.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

In recognition of the growing importance of processing as an outlet for fruit crops, the situation and outlook work in this area was strengthened. A special section relating primarily to processed non-citrus fruits was added to the June issue of the Fruit Situation report. The section summarizes the market position for processed fruits and presents background information on utilization of fruit crops: packs, shipments, and stocks of principal canned and frozen fruits; exports of selected fresh, canned, and frozen fruits; prices received by growers for selected fruits for processing; retail prices for various fresh and processed items; and per capita consumption of fresh and broad groups of processed non-citrus fruits. The information should be particularly helpful to the fruit industry at the start of the processing season for deciduous fruits.

A special study on apples was made at Congressional request. The study examined past trends in the U.S. apple industry, and evaluated longer term supply and demand prospects. Particular attention was directed to Washington State where the large plantings of recent years have caused concern about a potential substantial future increase in production. A special article on apple trends and prospects was included in the August issue of the Fruit Situation.

A paper on U.S. fruit and vegetable trends and prospects was presented in March at the Sixth Annual Agricultural Marketing Conference, at Ohio State University. Tables on per capita consumption of fruits and tree nuts were reconstructed to include Alaska and Hawaii back to 1960.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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CONSUMER PREFERENCE AND QUALITY DISCRIMINATION--
HOUSEHOLD AND INDUSTRIAL
Standards and Research Division, SRS

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for consumers to express to producers either pleasure or displeasure with available merchandise. To market agricultural products more effectively, it is necessary to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on consumers' attitudes toward old and new product forms of agricultural commodities, preferences, levels of information or misinformation, satisfactions or dislikes, and what product characteristics would better satisfy current consumers and/or attract new ones. It is also important to know the relationship between the consumption of one agricultural commodity and another in consumers' patterns of use, the relationship between agricultural and non-agricultural products, and probable trends in the consumption of farm products. Producer and industry groups as well as marketing agencies consider such information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increases returns to growers.

USDA AND COOPERATIVE PROGRAM

The Special Surveys Branch conducts applied research among representative samples of industrial, institutional, or household consumers and potential consumers. Such research may be conducted to determine preferences, opinions, buying practices, and use habits with respect to various agricultural commodities; the role of competitive products; acceptance of new or improved products; and consumers' ability to discriminate among selected attributes of a product or levels of an attribute, and the preferences associated with discriminable forms.

The research is carried out in cooperation with other USDA or federal agencies, State experiment stations, departments of agriculture, and land grant colleges, and agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology or other social sciences, in Washington, D. C., which is headquarters for all the research whether it is conducted under contract or directly by the Branch. The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years. An additional .2 professional man-year was devoted to research conducted under a transfer of funds arrangement.

PROGRAM OF STATE EXPERIMENT STATIONS

While the State Experiment Stations do not report any of their work in this area, a considerable portion of the work reported in the Economics of Marketing section of this report has similar objectives.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Consumer Preference

Interviewing and coding have been completed on a nationwide contract survey among homemakers to ascertain the frequency and patterns of use for selected noncitrus fruits, as well as the attitudes and opinions which influence their use or nonuse. Specific topics investigated included the kinds of fruits purchased, reasons for purchase or nonpurchase of specified fruits, qualities associated with particular fruits, and buying patterns. Additional data were collected on apples, the retail volume leader of fresh noncitrus fruit.

B. Quality Discrimination

To accommodate a greater proportion of the requests received for small group experiments in taste and visual discrimination and provide facilities for investigating a broader range of sensory evaluation problems, a laboratory tailored to such psycho-physical research was installed during the past year. The laboratory is used to ascertain, under controlled conditions, people's ability to discriminate among qualities or levels of a quality for food samples, or other sensory or visual stimuli, and the preferences associated with discriminable variables. The products which have been evaluated include new food forms developed in the ARS laboratories or variations of products already available. Studies have been conducted on apple juice concentrate, grape juice concentrate, powdered grapefruit juice, fresh orange juice, dried milk, canned peas, and dehydrated potatoes. Some examples of the types of problems investigated in the past year are listed below. The results of these experiments have not been published, but were reported by memorandum to the cooperating groups requesting the research.

Grape Juice Concentrate. An experimental grape juice concentrate was reconstituted in two ways: as a juice with two parts of water to one of concentrate, and as a drink with six parts of water to one of concentrate. These experimental products were compared with a grape drink and a grape ade currently on the market. Thirty-six subjects tasted and rated each of the four products, identified to them simply as "grape juice." There were no significant differences between the mean preferences for the commercial drink. The grape drinks were significantly preferred to the test product as a juice and to the commercial ade, however.

In a second test, the problem was to determine what ratio of water to the experimental concentrate was preferred. The concentrate was reconstituted at five levels, using 4, 5, 6, 7, and 8 parts of water to 1 of concentrate. Subjects tasted and rated their preferences for each of the five products.

Mean preference scores for the concentrate mixed with 4, 5, and 6 parts of water did not differ but were significantly higher than those for the concentrate mixed with 7 or 8 parts of water. The results indicate that a reconstitution at 6 parts of water to 1 of concentrate would be acceptable.

In addition, a series of studies was conducted to determine the effects of length of storage at various temperature levels on preferences for this product. Samples were stored at three temperatures (40, 70, and 100 degrees F.) and were evaluated at regular intervals during the following 8 months. After 8 months, the preference ratings for the samples stored at 70 degrees did not differ significantly from those for the samples stored at 40 degrees, indicating that the product did not require valuable freezer space. However, after approximately 6 weeks, the samples stored at 100 degrees showed a significant deterioration in flavor as evidenced by preference scores.

IMPROVEMENT OF CROP ESTIMATING PROCEDURES
Standards and Research Division, SRS

Problem. The Statistical Reporting Service produces a large number of current statistics pertaining to agriculture. Because of limited resources, statistical methods were devised with a view to producing the most information for the least cost. These methods are subjective in nature and are based largely upon self-selected samples from voluntary crop reporters who fill out and return mailed questionnaires. The information is generally collected in the form of relatives such as acres this year compared to last, and crop condition as a percentage of full crop. Persistent bias is removed by charting, and census or other check data are generally projected to form current estimates. Estimates based on these sample methods have proved relatively satisfactory over the years. However, in seasons when changes are unusually large, the changes may not be fully reflected in the appraisals and reports of the respondents to mailed questionnaires. In situations like this, when accuracy is needed most, the estimates may lack the required precision. Then, when estimates are translated into available supplies for the different commodities, price inequities may occur and, as a result, producers or the processors of agricultural commodities may suffer serious financial loss.

With the development of modern statistics, new methods based upon probability sampling have been developed. Although surveys based upon probability sampling are more expensive to conduct than the traditional self-selecting mailed survey, these new methods offer a means of increasing the precision and reliability of the estimates. Because of the need by the agricultural economy for high quality statistics, it is mandatory that the statistical theory and methods be developed and adapted to the collection of agricultural statistics. Some of the new procedures have already been introduced but there is an urgent need for a continuing research to devise efficient survey methods so as to make possible continuing improvement in the quality of SRS statistics.

USDA AND COOPERATIVE PROGRAM

The Department of Agriculture conducts a program of applied research designed to strengthen and improve the methodology used in collecting agricultural statistics. The principal disciplines involved are mathematics, statistics and probability, but other disciplines relating to a particular problem are brought to bear as required. Examples of these are plant physiology, cartography, and photogrammetry. The current program consists of 6.0 professional man-years per year devoted to the study of sample and survey methods, and 4.0 professional man-years working on methods for forecasting and estimating the yields of important crops. Work under this program is done in Washington, D. C., and in SRS field offices located in the States concerned.

PROGRAM OF STATE EXPERIMENT STATIONS

No work reported in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

1. Sour Cherries. Due to a reduction in budget, the surveys for the three pilot States (New York, Pennsylvania, and Wisconsin) were not conducted during 1963 and the survey in Michigan was reduced to 90 sample orchards. This reduction in sample size in Michigan contributed to an increase in the coefficient of variation for the pre-harvest survey to about 30 percent for weight of fruit per tree instead of the 12 percent for previous years. This sampling error is due almost entirely to variation in fruit count per tree.

Weekly development observations were made on two trees in each of six Michigan orchards, two orchards in each district. Twelve samples of 20 cherries each were used for observing growth and drop patterns between bloom date and maturity. Visits were made biweekly with emphasis on obtaining more carefully controlled and recorded data on the pit hardening cycle. The major point of reference for fruit maturity has been bloom date. It is hoped that more current maturity reference points will be provided by the pit hardness index. Improvement in ability to place a sample in its proper stage of maturity is essential when slope of drop and development curves varies so much as the maturity of the fruit progresses.

With the conclusion of the 1963 surveys, research is fairly complete for most phases of this study. Except for some continued small scale development work and a more complete sampling frame, the program for forecasting of cherries in Michigan and possibly New York, Pennsylvania, and Wisconsin is ready for extension to an operational level. For Michigan, it is suggested that about 900 sample orchards would be required to reduce error to 5 percent at the 68 percent confidence level for the preharvest survey. The old sample frame of 100 areas is not adequate for the recommended operational level. Updating of the area frame or an area frame supplemented by producer lists should be investigated. If only a list frame is used, this should be nearly complete and any incompleteness should not be confined to certain classes of orchards or trees.

2. Grapes. Development studies were conducted in Michigan from 1960 through 1963. The purpose of the study was to determine the feasibility of objective forecasts of grape production.

A continuing series of data has been collected. The project was conducted on three representative vineyards. Visits were made to the vineyards twice monthly from July until September harvest. At the first visit, three rows were systematically selected and within each row one vine was selected at random. These vines were referred to as "count" vines. On these vines bunches were counted and every fifth bunch was marked. On the marked

bunches all berries were counted. Also, at this time an adjacent vine (same row) was selected and a count of bunches made. These vines were referred to as "clip" vines because after the bunches were counted every fifth bunch was removed for laboratory determinations. Weight per bunch and number of berries per bunch was recorded. On subsequent biweekly visits the bunches were again counted on "count" vines to derive missing bunches. Also, another "clip" vine was selected and data were collected as outlined above under the "first" visit. Marked bunches on the "count" vine were clipped on the last visit and "clip" vine determinations were made on the bunches. In addition to the continuing series of data, a special 1962 preharvest study was conducted on 25 orchards. The purpose of this study was to provide more precise estimates of reliability and forecast relationships.

Analysis of data indicated that droppage of bunches from July 1 to harvest was insignificant. An analysis of variation of "clip" vine bunch counts (considering bunch counts as though they were made at the same point in time in a season) suggests that vines within rows are not related because of their proximity to one another. Therefore, it appears that adjacent vines can be sampled as efficiently as vines spaced further apart in the row. Variation between vines over years was large as compared with variation between rows within the same vineyard and between vineyards. For the 1962 preharvest survey, an analysis of variation of bunches per vine indicated that when cost of data collection between vineyards was high as compared with costs between rows, a sample of two or more rows per vineyard and about two or three vines per row should be sampled. Another analysis of variation from the laboratory determinations of berries per bunch suggested that the optimum number of vines per vineyard would be about seven.

As mentioned above, July counts of bunches per vine may almost be used directly to forecast final bunches. Also, a July regression estimator of berries per bunch gives a good forecast of final berries per bunch. Bunch weights vary but it is expected that the number of berries per bunch contributes more to the variance of bunch weight than does berry weight. Results of this study indicate that accurate forecasts of yield are possible; however, larger samples are needed to refine forecasting parameters and test hypotheses that have been made.

